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FINAL REPORT
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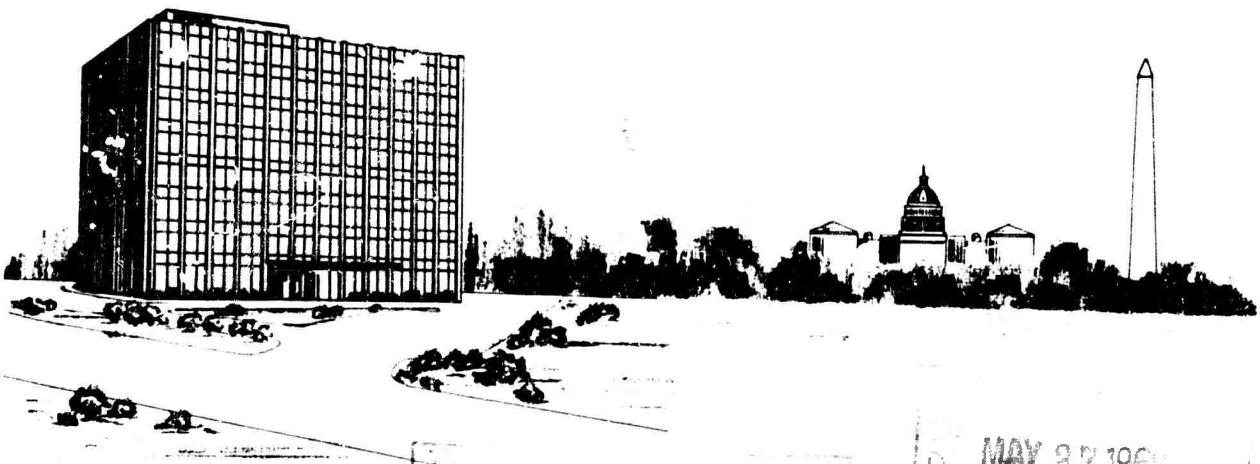

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EXPLORATION OF ORAL/INFORMAL TECHNICAL COMMUNICATIONS BEHAVIOR

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FINAL REPORT

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Summary

Exploration of Oral/Informal Technical Communications Behavior

This study explored and defined the boundaries of the field of informal communications behavior, based on five kinds of scientists and engineers in four types of employing organizations. A major purpose of the study was to determine the kinds of management decisions that are needed in order to enhance research productivity by improving informal research communication.

Informal discussions were held with 107 research directors and chairmen of university science departments. Standard interviews, questionnaires and communications incidents memoranda were obtained from 326 project directors who were actively engaged in research work.

Information was collected concerning (1) how informal and formal technical communications are interrelated, (2) how difficult-to-obtain information is located, (3) the values of informal research communications, (4) effects on research motivation and innovation, (5) information exchanges and newsletters, (6) intra-organization communications, (7) inter-disciplinary communication, (8) directories of specialists, (9) visiting of other laboratories, (10) meetings and conferences, (11) use of communications technology, (12) restrictions on information transfer, and (13) the functions of informal communications in the research process.

The information acquired for this study was evaluated in terms of problems stated and suggestions made by those who volunteered to participate. A list of recommendations for future decisions and actions for improving informal research communications is presented.

TABLE OF CONTENTS

LIST OF TABLES

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Exploration of Oral/Informal Technical Communications Behavior

Introduction

The research reported herein was designed to explore scientific and technical communications behavior of scientists and engineers. The project primarily concerns informal, interpersonal communication of scientific and technical information. Commenced at the suggestion of the Federal Government's Interagency Committee on Scientific and Technical Information (COSATI), the study was sponsored by the Advanced Research Projects Agency of the Department of Defense, and the contract was administered by the Army Research Office - Durham (DAHC-04 67 C0004).

The impetus toward a government-sponsored exploration of informal scientific and technical communications was provided by the COSATI Task Group on National Systems for Scientific and Technical Information. The Task Group previously had suggested that a series of information studies be undertaken, among which was a study of formal information systems by Systems Development Corporation entitled, "Recommendations for National Document Handling Systems in Science and Technology " (PB 168, 267), December, 1965. The present study was suggested in order to explore and define the boundaries of informal scientific and technical communications and their interactions with formal information media. Thus, the present study, unlike other information studies, was primarily meant to be an effort in problem definition and to provide information about needs for further research. The Statement of Work of the Request for Proposal stated:

> "The purpose of the study is to explore and define the nature and boundaries of processes by which meaningful scientific and technical communication take place without the aid of formal documentation. Thus, the study is an analysis of the

role that oral/informal technical communication plays in the conduct of the nation's science and technology.

"The study will provide estimates of the relative importance of various modes of oral/informal technical communication, the conditions under which they are most likely to be used effectively, the mechanisms and technology that promote their use, their interfaces with the formal documentation processes, and their relationships to cultural patterns that have evolved to motivate scientists and other technical people in the work they do. A specific product of the study will be a time-phased program for measuring the national effort expended on selected modes of oral/informal communication and for recommending national policies that would enhance scientific and technical productivity through better use of such modes of communication."

The following questions in the Request for a Proposal led to the present study. They typify other issues that need to be resolved:

"1. Can oral, informal communication be defined with sufficient precision to permit a study of it?

2. Does time spent on oral/informal communication accurately portray its economic importance, or are there other, more reliable, indicators of its importance?

3. Are there stylized patterns involved, such as more emphasis on vertical communication in organizations rather than horizontal, or vice versa?

4. How do technical meetings fit into the picture?

5. What are the constraints that inhibit effective oral/informal communication?

6. How much do the behavioral scientists already know about this field?

7. Do we have any hard facts to go on, and how should more facts be accumulated?"

Thus, we were asked to explore the nature of scientific and technical communications that take place without the aid of formal publications, and to obtain a clear description and definition of the role played by informal communication techniques in research. The present study, therefore, is an exploration of the role that informal scientific and technical communications play in science and technology, and of the boundaries between informal and published communications.

For the purposes of this study, informal scientific and technical communications were defined to include oral communications, such as lectures, discussions, telephone conversations, technical meetings, and social gatherings. Also included are written memoranda, proposals, and pre-publication papers. In other words, informal communications are those that involve person-to-person interactions, and formal publications designed for mass dissemination of scientific and technical information were excluded.

An exploratory study of the facts of informal scientific and technical communications must be based on empirical observations, if it is to be of value. But a suitable study need not be limited to a single method of gathering information. A number of techniques of inquiry have been developed that can be applied to study informal scientific and technical communications. Each technique can yield a different kind of information, and each can apply more appropriately to one kind of scientist or engineer than to another.

Before successful exploratory investigation of informal scientific communications can be achieved, two procedural questions must be answered:

1. How can descriptive information best be accumulated about informal scientific and technical communications?

2. How can the resulting data be evaluated to produce the desired recommendations?

The research design for an exploratory study must be comprehensive enough to assure that the major sources of useful descriptive information are investigated. Data must be obtained in such a way that it can be evaluated quantitatively in order to produce the desired research product: a time-phased program for measuring the national effort expended on informal scientific and technical communication. Only quantifiable data based on empirical observations can be expected to result in sound and realistic recommendations as to how research productivity can be enhanced through informal scientific communications.

In view of the above considerations, it was determined that this research will seek to document the existence of the widest possible variety of facts about the informal communications of scientists and engineers. Any effort to estimate the frequencies of their behaviors was to be considered purely peripheral and suggestive, because many commonplace and trivial items can occur with high frequency.

Thus, we tried to learn about highly unusual kinds of informal technical communications, as well as about those that are relatively commonplace. Our primary emphasis, therefore, was on exploring to learn as much as possible about the diversity of informal communications, methods and problems. We talked with 106 Chairmen and Directors of Research and with 326 of the Project Directors they recommended. The consideration, assistance, and general contributions that they made testify to their broadness of perspective, and to the importance that they attach to problems of informal scientific communications. We believe that this report substantiates values they place on informal communications to a very high degree.

This final report is organized into separate articles, one for each type of study that produced the data required for a better understanding of informal scientific and technological communications.

This has resulted in a degree of redundancy from one chapter to the next, since some overlap in both introductory and substantive material has been retained so that each article will be self-contained and independent of other sections of the report for context and continuity.

It is realized that, when the entire report is read as a unit, the reader will encounter identical or highly similar passages and data from one chapter to another - the advantages of being able to read each article without necessarily having to refer to other sections of the report are believed to outweigh the effects of this redundancy.

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Chapter I

Informal Communication of Science Information: A Review *

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William P. Gloege

In the past, study of scientific and technical communication has largely been devoted to problems that concern formal publications. But some observations and ideas about informal scientific communications have appeared in the literature. In order to determine the state of knowledge concerning informal scientific communications, we scanned approximately 2,000 titles in the general area of scientific and technical communications. About 300 documents were examined, of which about 35 contained extended discussions of informal scientific communications. The information on informal scientific communications is scattered widely throughout the research literature of many disciplines. This review is intended to bring together information from the important writings on informal scientific communication.

Abelson (1966) states that there is a divergence of opinion concerning the seriousness of the current "information explosion." Established investigators find that much of their need for information is met through participation in "invisible colleges," and through informal communications in general, along with scanning of a few journals. Using this "short cut" method, it is possible that they could duplicate much previous research, but this is usually not the case. In spite of the divergence of opinions concerning the "information explosion" and the communication problems that it is creating, politicans, scientists and others agree that quick, selective information retrieval and dissemination are desirable. This would seem to indicate a need for some reliance on the use of informal communication.

* This research was supported by the Advanced Research Projects Agency, Office of the Director, Defense Research and Engineering, and was monitored by the U. S. Army Research Office-Durham, under Contract No. DAHC 04 67 C0004.

Voight (1961) classifies the information-gathering behavior of scientists into three types: (1) the current approach; (2) the everyday approach; and (3) the exhaustive approach. The "current approach" refers to a scientist's need to keep up-to-date with current progress and developments in the field. The "everyday approach" refers to the need for specific information directly connected with the research work and problems at hand -- a bit of data, a method, an equation, etc. The "exhaustive approach" is the scientist's need to find and check all relevant information on a given subject, as happens when a researcher starts to work in a field that is relatively new to him.

In the 'current approach" conversations with colleagues seem to be the most important source of information on progress in the field. Meetings and symposia are another source of current information on new developments. However, much of the information received at meetings comes from casual conversation rather than formal papers. Correspondence is important, Voight finds, when the field is narrow and the number of workers is few. He also says that information received informally from colleagues and associates probably is the most important source. It is often the fastest source and has the advantage to the user of supplying information based on a knowledge of the specific problem at hand, and of allowing questioning to bring the information to the desired level of clarity.

Hertz and Rubenstein (1953) measured communications behavior of research groups. It was realized that to gain a clear understanding of communications behavior, research was needed into the actual motivation, content and outcome of specific communications. Through interview and questionnaire, it was determined which events, individuals, and communications media had provided useful information. The study indicated that knowledge of communication patterns is needed to understand the operation of research groups.

Values of Informal Scientific Communication

The literature contains many discussions of the importance of informal communications. For example, Beckett (1961) emphasized the importance of the formation of scientific groups for informal communication, saying that such groups constitute an invisible college, in the same sense as did those first unofficial pioneers who later banded together to found the Royal Society in 1660. Such groups, he said, ought to be encouraged, because they give status pay-off to the speaker without increasing the papers that would otherwise be written to this end. Taylor (1962) noted that we seem to be able to separate signal from noise in oral communication better (on a short-term basis) that in written communication.

Rubenstein (1961), writing on researchers' needs for information, recommends increased study of informal information exchange methods, such as correspondence and personal visits with fellow researchers. He states that it would be useful to researchers to have information technologists locate other researchers through directories, and to provide summaries of who knows what, or who is doing what in a particular field.

Robertson (1961) pointed out that personal contact is of overriding importance in the use of technical information to produce industrial innovation. Other channels of communication are essential, but without the addition of personal human contacts they may be, and often are, of little value by themselves. There are plenty of examples to be found of the way in which a flow of paper, unaccompanied by adequate human movement, can produce ideas and proposals which are remote from reality. Personal contact also is vital to the kindling of enthusiasm. Menzel (1959) studied 77 university scientists and concluded that "conventional channels" are sufficient when the scientist knows what he is looking for. It may be, however, that finding important information "accidentally" is a function of the amount of informal communications participated in.

Maizell (1960) investigated the possibility of a relationship between the use of technical literature (and other information sources) and creativity. His sample consisted of 94 chemists from one industrial research laboratory. Creativity was measured by supervisor ratings, the AC test of Creative Ability, the Differential Reaction Schedule, and to a limited extent, the number of each scientist's publications and patents. Maizell noted that a majority of the most and least creative chemists found both reading and discussions of about equal importance as a source of ideas, but more of the creative chemists found reading more stimulating than discussion. Also, the most creative chemists preferred reflective study and thought before discussion with colleagues. Glass and Norwood (1959) reported that the majority of scientists they studied had indicated "general conversation" as the most frequent source of information about work important to the development of their own ideas.

Techniques of Informal Scientific Communication

Garvey (1965) observed that research psychologists seeking scientific information may satisfy different information needs through different media. Fussler (1959) also noted that different techniques and channels are used to meet different needs. In addition, Garvey (1965), Shilling, Bernard, and Tyson (1964), and Aims (1965) all have related nature of the work or type of research activity to variations in ways of informal scientific communications. Also, there was speculation about a relationship between age and differences in scientists' communication habits. Libby (1959) states that although the student is required to use the literature, the scientist (when he becomes older and more established) tends to rely primarily on oral communication.

Shilling, Bernard, and Tyson (1964) questioned bioscientists about informal communications to determine if there were differences among individuals in their use of informal scientific communication. Their major finding was that informal communications channels are widely used. They noted age, sex, and laboratory group differences, but they were overshadowed by the similarities among the groups. Other factors which may affect communication practices of a discipline were stated by Glock and Menzel (1958) as follows:

> "The dispersion of work over few or many institutions; the rate of personnel turnover, the closeness of the field to a theoretical base; degree of collaboration with other specialties, disciplines and applied fields; the location in academic institutions, special research institutes, government establishments, or industrial enterprise."

Glock and Menzel (1958) described a similarity in the method of obtaining specific information among a group of university scientists (N=60). Sixty-five percent of the zoologists, 48 percent of the biochemists, and 45 percent of the chemists interviewed said that they "would ask a colleague" to obtain specific information in their <u>secondary</u> fields of attention. Aims (1965) found that there were similarities in the information-seeking habits of "pure research" chemists and physicists. The "pure research" scientists considered abstracts and original papers to be their most important source of specific information. Out of the 3,021 chemists and physicists questioned, Aims reported that 36-45 percent of the chemists and 46-55 percent of the physicists utilized library information departments as a source of specific information in their research area. In addition, Aims found that 58 percent of R & D scientists behaved in a similar fashion to the "basic" researchers. Aims' survey, however, did not find a great preference for personal contacts. The author concluded that due to the nature of their work, his subjects were more dependent on the literature than industrial scientists and technologists.

Similarity also has been noted among disciplines in maintaining awareness of current developments. Both the chemists and physicists in Aims' (1965) study favored meetings and conferences along with reviews. Herner's (1950) medical scientists (N=500) reported that face-to-face communication is one of the three best methods of keeping up-to-date in their field. These results differ from the findings of Glock and Menzel (1958) who asked their subjects to rank various channels of communication (formal and informal) for value in calling attention to developments in their primary field. Only 20 percent of the biochemists, 25 percent of the chemists, and 15 percent of the zoologists chose an informal channel. Similar findings resulted with regard to their secondary fields of attention: 15 percent of the biochemists, 31 percent of the chemists, and 21 percent of the zoologists. However, when the authors considered the first four most important channels in rank order, they found that nearly 100 percent of the zoologists, 80 percent of the chemists and 58 percent of the biochemists included at least one of the forms of person-to-person communication among the four most important channels. Technical information was found and disseminated in a variety of ways, and informal methods of communication were indicated to be very important.

Garvey (1965) studied research psychologists' oral and written means of disseminating information contained in 1068 technical reports. The information contained in 88 percent of the reports had been reported orally. About 50 percent had been presented orally on one occasion, and 38 percent had received more than one oral presentation. Most oral presentations tended to take place prior to distribution of the technical report, 52 percent having occurred before and 36 percent after distribution.

Glock and Menzel (1958) pointed out that a wide range of practical research knowledge does not appear in the literature, such as special procedures, experiences in the use of apparatus, and hints as to pitfalls in the application of given techniques. Garvey (1965) asked 1263 psychologists to rate a variety of written and oral scientific communications relative to their most information-demanding activities. Book users tended to rate books and journals as "very important," while non-users ranked orally communicated information second to journals as "very important." There were few differences in the forms of communication utilized by book users and non-users, but there was a tendency for non-users to view informal media as more important to their work. Even though the book users rated informal communication as less important than non-users, it was found that a majority of the books used were discovered through informal sources, such as recommendation by colleagues. The study indicates that the sources of information most valuable for United States psychologists (N=73) were: United States journals (85 percent); discussion in one's own institution (61 percent); reprints(53 percent); preprints (51 percent); and correspondence (48 percent).

Fishenden (1959) determined the methods that 63 researchers considered most effective in bringing information to them by using interviews and diary cards. Eleven percent used personal recommendations as a source of information. The 63 who contributed diary cards indicated that nearly 30 percent of their task-related information was acquired orally. Twelve percent of the diary card items were based on either oral or written private communications. In 21 percent of the task-related searches a colleague was the first source of the information. In more than half of the task-related searches, research personnel utilized colleagues, personal files, and local departmental sources as their first source of information.

Cudlipp (1961) asked 1,000 technologists in 127 organizations where they seek technical information. Only 22 percent mentioned the literature, while the remaining 78 percent said they would try to find someone, inside or outside the firm, who could tell them what they needed to know. Seven hundred of the technologists were engaged in problem-solving at the time of the survey. When this group was asked how they go about solving their problems, only 12 percent said they would consult the literature. Hodge and Nelson (1965) asked biologists: "How do you prefer to select your reference sources?"

The answer was that only 17.6 percent stated "word-of-mouth" (N=119).

Ackoff's (1958) study of the scientific activity of chemists (N=1500) reports the following percents of time spent in communication by chemists during working hours:

general discussion	10.0 percent
oral, non-discussion	8.9 percent
written, unpublished	9.0 percent
written, published	4.8 percent

It appears that about 28 percent of the chemists' working time was spent on informal scientific communications.

Murtaugh and Payne (1962) concluded that oral communications and correspondence constitute the fundamental, most powerful, immediate, and effective means of conveying information in the scientific and professional world. They went on to say that methods of personal communication are perhaps the dominant factors in the rapid postwar advancement of science. Personal interaction or informal communications have (in the opinion of many scientists) replaced publications as the primary means for the initial and immediate dissemination of research results, according to the above authors.

Intra-Organization Communications

Bondi (1962) declared that it is only by personal talk between scientists that unformed ideas can travel from one mind into another, and that the motivation for different lines of attack can be communicated and discussed. It is only by talking that the scientist can discover which point of his approach, seemingly so clear to himself, others find particularly unacceptable. Pelz (1956), discussing the scientists' working environment, said the scientist may need frequent (daily) contact with several scientific colleagues who, on the average, have been employed in settings different from one's own, who stress values different from one's own, and who tend to work in scientific fields different from one's own. At the same time, frequent contact with at least one important colleague who has similar professional values appears to be a significant condition in stimulating research productivity.

Glass and Norwood (1959) studied 50 biological scientists and found that they have a very heavy reliance on verbal communications with scientists working in their own areas of research. When questioned on methods whereby they actually learned of work crucial to their own, the scientists produced a list of 346 items of which 30.6 percent were informal communications. Hodge and Nelson (1965) produced a comprehensive study of communication needs of biological scientists in a large laboratory. The scientists who returned their questionnaires noted that, within the laboratory, several people might be working on similar things, but each may not have enough knowledge of what the others are doing. In addition a need was noted for better cross-stimulation of ideas and methods. Current seminars were said to be much too formal and not publicized sufficiently.

To improve communications within their organizations, biological scientists proposed, among other things, extensive changes in seminar programs. In particular, participative, division-level informal seminars and specialized study groups were desired. They wished them to be conducted at a highly technical level in order to learn who is doing what, and why. They suggested that briefings should be reduced. They also desired frequent discussions with scientists from the outside, and general symposia sponsored by their laboratory. There was a need noted for more discussion between workers in closely allied fields. Finally, it was suggested that the need for advisory services could be filled by providing scientific advisors and an advisory group of eminent scientific specialists who could provide assistance in particular problem areas.

The scientists questioned by Hodge and Nelson (1965) produced one comment on communications in interdisciplinary research. They pointed to the existence of uncertainty concerning the role of information communications within and among research and development teams. It was noted that knowledge of the means for exchanging information systematically, either formally or informally, was too scant among team members. A single suggested solution was that the organization should develop an educational program to inform users on what can and cannot be done to acquire and to disseminate information.

Timeliness and Current Awareness

One of the major problems concerning transfer of scientific information involves the timeliness of the information required with respect to the progress of a research project. The only mention of this problem in the literature appears to be due to Rubenstein (1961) who made the following suggestion:

> "What may be needed. . . is a direct assignment of information specialists to projects in order for them to get to know the actual research problems and the men working on them. . . Information specialists can provide a degree of filtering for the bench researcher. . . . Although such assignments are often inefficient in terms of direct costs, they are extremely effective in terms of accomplishing the mission."

In a study of 77 scientists by Glock and Menzel (1958), 24 percent stated that they had received information too late to be utilized. The information sought often is at the forefront of a field, and frequently it was not available in print at the time it was desired. Even when much of the information can be found in the literature, informal communication may be faster than formal means.

Current awareness services, i. e., lists, previews, and newsletters, have been designed to inform scientists of research projects prior to publication. However, Bottle (1965) noted that many scientists do not use channels provided by information services, but turn instead to their own informal channels to keep themselves up to date. Berul (1965) studied this problem, but he had difficulty gathering data on how scientists obtain the information they need to keep up to date in their fields. This was due to the fact that current awareness information is extremely encompassing and is gathered and used in highly subjective ways.

Green (1967) reported on the Informal Exchange Group (IEG) which sought to provide rapid scientific communication in sharply focused fields of biological inquiry. A chairman ensured that all active workers in a field became members of his group and that communication among them was maximized. This was done by circulating any communications submitted by any member to all other members of his group. No censorship was exercised, and the IEG Memoranda were treated as personal communications. According to Green, at least 90 percent of the important papers in his field were being processed through IEG before the groups were terminated because of a dispute with journal editors and subsequent withdrawal of funds.

Abelson (1966) was of a different opinion on the usefulness of the Information Exchange Groups. He noted that the membership of the IEGs grew very rapidly from 56 members and 10 preprints circulated in 1961, to 3625 members and 1.5 million copies of preprints circulated in 1966. The potential was for even greater growth, if the system were allowed to remain in existence. Ultimate costs might range from $10 million to $100 million, Abelson observed. He expressed the opinion that the quality of the informal material circulated suffered as the membership grew, and claimed that the speed with which the informal documents circulated is exaggerated.

It was suggested in reports by Bernal (1959) and by Hodge and Nelson (1965) that information specialists could be used to direct researchers' attention to the current information they need in the literature, and also to report on what is being done in other divisions of the same organization. It was suggested that one way of alerting scientists to new literature would be to send each of them copies of the tables of contents of newly received issues of journals. But a note of caution came from Egan and Henkle (1956):

"The sheer volume of information to be stored and transmitted makes it impossible to commit any considerable responsibility to the personal carrier; he is, in the very nature of his service, a selective agent and his criteria of selection may or may not be those best suited to the purposes of the inquirer."

The need of scientists for better networks of personal contacts has been commented upon by Brownson and Morse (1959), Aims (1965), Rubenstein (1965), Nelson and Hodge (1965) and Berul (1965). It was noted that "biological storage" facilities in the form of well informed brains of colleagues are used extensively. It was suggested that these facilities could be expanded to provide access to greater numbers of specialists. The method generally suggested is to develop "who knows what" directories of specialists.

Meetings and Conferences

Murtaugh and Payne (1962) point out that formally arranged meetings, conferences, seminars, symposia, and colloquia are the basic framework of the process of personal interchange amongst scientists. It is in meetings of this kind that new discoveries, major findings, and new concepts are first presented and discussed, considerably in advance of the more permanent publication. In addition to these more formal gatherings there are almost numberless informal meetings.

Among the situations and conditions conducive to personal contacts for exchanges of scientific information, meetings and conferences are said to be among the most important. Hodge and Nelson (1965) found that technical meetings were considered second only to the published literature as a source of scientific information. Commenting on the role of informal communications vis-a-vis the huge increase of formal scientific communication, Brooks (1963) noted a trend toward more meetings, conferences, and visits among scientists.

Bondi (1962) has also drawn attention to meetings, the essential value of which, he says, lies in the informal, personal contacts they encourage. He stresses that for valuable informal communication to occur, personal confidence is necessary and that essential to this confidence is personal contact. Garvey (1965) found that psychologists attending meetings, conventions, or conferences felt that the main function of paper presentations was to stimulate discussion, not necessarily within the convention session, but informally thereafter. Only 10 percent of psychologists involved in research or research guidance stressed the meeting presentation or conference as "very important" with respect to their most information-demanding activity (N=986). Hodge and Nelson (1965) found that about 70 percent of those biologists who attended scientific meetings gained significant scientific information from them (N=161). This information was obtained in a variety of ways: paper reading sessions (54 percent), informal discussion (45 percent), symposium (40 percent), motion picture or TV (9 percent), and exhibit (23 percent). Underwood (1961) also noted the important role of exhibits in the communication of scientific and technical information.

Not only members, but also many non-member scientists attend meetings of technical societies, according to Hodge and Nelson (1965). Garvey (1965) found that 150 research psychologists not attending conventions requested information on the presentations as a source for their individual research. About 76 percent of the non-attenders requested a copy of the presentation after receipt of the convention program and/or abstract of papers, while 24 percent requested it after a colleague's suggestion, personal contact with the author, or another informal source.

Hodge and Nelson (1965) investigated biological scientists' oral presentations of biological scientific information. They found that 45 percent of 161 biologists have made an oral presentation of scientific information. The presentations were distributed among scientific meetings, colloquia outside their labs, colloquia inside, and scientific committees. Almost 7 percent of the respondents reported that, although they had not made any oral presentations, they would like to do so. The scientists were questioned about presentations of papers, addresses at symposia or the like within the preceding year. Almost 17 percent had given such presentations.

Orr, Coyl and Leeds (1964) said, however, that meetings are becoming less effective and more wasteful of scientists' time, particularly that of senior scientists. They noted, further, that scientists in all disciplines complain of too many meetings, and of duplication of presentations among meetings. The above investigators stated that scientists are permitted, and even encouraged, to deliver virtually the same lecture at meeting after meeting.

Hodge's and Nelson's (1965) replies from Army biological scientists suggested a nec . for attendance at national meetings at least once a year for each scientist so that information can be obtained from more outside workers. Two weeks of temporary duty at outside labs engaged in related research was suggested for principal investigators. More funds also were seen as being needed for attendance at outside conferences and to visit other laboratories.

Security

Of all the references reviewed, only Hodge's and Nelson's (1965) empirical study of Army biological scientists produced an indication that national security classification requirements created communications problems for scientists. They summarized the responses of scientists to their questionnaire as follows:

> "Much information is not published for security reasons. However, this is done to such an extent as to discourage publication. This leads others outside Government service, but in the same field of investigation, to publish first. Also much useful information is lost in filing safes with no benefit to outsiders."

Security considerations have been so omnipresent that they tend to restrict information transfer. Perhaps this effect is self-imposed by scientists unnecessarily. The one suggestion that was forthcoming from the Hodge and Nelson (1965) sample was to hold more classified symposia for discussion of security-classified programs.

Summary and Discussion

A large portion of publications on informal scientific communications dealt with efforts by authors to convince readers of the importance of informal scientific communications. But there were a few comments to the effect that good use of informal communications is dependent on being aware of what is in the scientific literature. In general, however, there is a strong tendency for writers to express highly favorable opinions about the values of informal scientific communication. Most empirical studies reviewed were based on data that bear little or no relationship to hypotheses discussed in the literature. Only a few empirical studies obtained observational data on what scientists do when they communicate informally (and why). Those studies which did report on data were limited to no more than three disciplines per study. The studies that report data are not comparable due to emphasizing different problems and using different methods.

A number of studies found that important scientific information often is acquired "accidentally" through the media of informal communication. And much practical research detail is circulated informally. Practical research information often is related to (1) special procedures, methods and techniques; (2) pitfalls of application of techniques; and (3) experiences with the use of apparatus.

Researchers who use only abstracts and other formal guides frequently learn about published information after research deadlines have passed, and sometimes after the research is in final report form. Often, however, informal inquiries supplement published information to provide leads to sources that may not be published in places where the scientist initially thinks that they should be found. On many occasions informal inquiries produce information about locations of publications much faster than use of literature guides and indexes. A large number of the studies and comments on the use of informal communication recorded that many scientists turn to their own informal channels to obtain information they need to keep up to date in their fields. The information obtained is encompassing and is gathered and used in highly subjective ways. Certain groups of scientists (Information Exchange Groups) have, in the opinion of some authors, maximized current awareness via preprints and other information communications. However, this is a controversial issue. Other comments in the literature indicate that these Information Exchange Groups are not useful enough to justify their expensive existence.

An especially important function of informal communications appears to be its contribution to the development and exchange of new ideas. New ideas are the tapers that light off new research efforts and provide the theoretical guidelines for scientific advances. For example, there is comment in the literature indicating that personal contact is of overriding importance for industrial innovation.

Related to the importance of informal communications for creativity is the motivating effect on research efforts produced by informal exchanges of ideas and information. The curiosity that leads to sustained research activity frequently has basic roots in previous informal communications. One sociological study of a group of scientists found that contacts with colleagues in either the same or in different fields seems related to research productivity. Much of the "contact" referred to involved informal communication. There are a few remarks in the literature to the effect that scientists go to meetings of scientific societies to discuss problems and ideas and to keep abreast of who is doing what in their fields. For many of them the main importance of reading papers is that they stimulate later informal discussions. National meetings, it has been noted, on the other hand, are organized with too much overlap between sessions.

Several sources in the literature mentioned that scientists value participative, informal seminars at a high technical level in order to learn who is doing what and why. At least one writer contended that scientists are by-passing the formal channels of scientific communications in favor of contacting directly those whose work most concerns them. One survey of biologists showed that 70 percent of attendees at national meetings gained significant scientific information from meetings by informal discussions with individual scientists. The literature revealed that interdisciplinary research team members may lack knowledge of the importance and means of mutually exchanging information systematically. One source commented that information specialists should be assigned to research tasks to better learn what the real problems are. Comment exists in the literature indicating that security classification of certain information inhibits, to some degree, the amount of exchange necessary to progress in relevant fields. A need for more classified seminars was noted. There do not appear to be sufficient facts in the literature to warrant generalizations about any of the major problems and issues that involve informal scientific communications.

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Chapter II

Current Research on Informal Scientific Communications

Warren R. Graham

A number of studies in the field of science information services are presently being conducted. Although most work is directed primarily at solving problems concerning formal communications, informal communications are also receiving some attention. In order to provide the most up-to-date information to supplement our literature review, we contacted six researchers who are actively engaged in scientific communications research. They were asked to contribute whatever information they had acquired about informal communications behavior of scientists. We report on their informal comments in order to be able to align ongoing research with recommendations.

Thomas J. Allen, of Massachusetts Institute of Technology, has been studying "key" individuals in several laboratories in their role as communicators, and the function of scientific information in R&D efforts. The subjects are engineers and scientists in industrial organizations. He and his assistants are looking at the structure of the informal network within an organization, and at the factors that influence the structure, such as:

1. The formal structure of the organization, i. e., how they lay out the communications net on the organization chart and who works with whom;

2. The informal organization structure, i. e., who collects for lunch and socialization in friendship;

3. The physical, spacial layout of the office space.

The research identified sociometric "stars" who were cited frequently as discussion partners or as sources of information. When they compared the stars with the remainder of the people in the laboratory, they differed significantly from them in their communication habits. They provide the interface between the formal and informal communications. The stars are more closely acquainted with the professional scientific and professional engineering literature than the average man in the lab is. He suggested that such key individuals could be made the principal figures in document transfer and information retrieval systems of a laboratory. He notes that there are different kinds of individuals in this role and that it isn't a unitary role. They perform the functions of adding to available information; they provide transfer of information or they give consulting advantages. Allen contends that there may be an inverse relation between the quality of the work done and the extent to which people use informal sources outside of their own organization, and a positive (direct) relation to quality with respect to sources within the organization. There seems to be a discontinuity at the organizational boundary.

Finally, Allen suggested that researchers in scientific and technical information topics should stress the distinctions between technologies and sciences.

William D. Garvey, of Johns Hopkins University, has been engaged in research on information exchange through an interdisciplinary approach with psychologists, sociologists and information specialists participating. The studies emphasize the interrelations among various media of formal and informal communications, and differences among eight disciplines in information use. The plan for this extended research is similar to the study of psychologists, which was done in collaboration with Belver C. Griffith. Again scientific communications at annual meetings of the scientific societies are the point of departure from which information transfers are traced. Griffith emphasized that communications appear to be strongly influenced by the facilities and structure of the local setting, and the goals and characteristics of the discipline, and the state of the field can affect very much the usefulness of a given communication. Most of the barriers between scientists seem to be more easily resolved with informal communication than through the formal. We can't shape formal communications to fit the characteristics of all scientists. One very distinctive semantic characteristic of informal communication is that scientists interact very quickly to establish that they are talking about the same thing and get down to the real details. He observed that for every formal channel there is a group of informal media that have been established to support the formal. If you disturb one of these without giving consideration to the other, you get into trouble.

Richard S. Rosenbloom, of Harvard University, has been studying large groups of engineers and scientists in the field of electronics in their employing companies and as members of selected divisions of the Institute of Electrical and Electronics Engineers. He has noted differences in the use of information communication between people of different backgrounds. People with higher educational level (e. g., Ph. D.'s as opposed to Bachelors, or people who are more active in professional societies) orient much more of their communication to people outside of their own company. The others tend to concentrate on sources available in the company, either documents that exist in the company or informal communication with other technical employees within the same firm. There also seems to be a substantial difference between the pattern of information communication in supervisory work and in first level technical work. He remarked that the quality of the information channels depends upon a lot of things within the organizations which at first glance don't have anything to do with communication such as promotion policy and policy with regard to supporting memberships in professional societies. It has to be studied as one aspect of the social system.

Albert H. Rubenstein of Northwestern University has had a long series of studies involving information problems in science and technology. Currently he is studying the information-seeking behavior of scientists and engineers and is relating behaviors observed in real settings to psychological behavioral theory and to sociological theory of organizations.

Rubenstein's primary emphasis was on the lack of available evidence to support theories about the relation of information acquisition to contribution of innovations or idea production. He contends that much of the literature is discursive rather than factual and contains many contradictions about the influence of communications on research output. He and his students are aware of the complex problems of individual differences in information acquisition, and they are developing experimental researches to clarify how they influence research efforts. Thus, for example, a pilot telephone system has been installed in a research department of a hospital, consisting of speaker, phone and automatic dialers. Calls made to specific numbers allow scientists to report on searches of the literature.

John S. Gilmore, of the University of Denver, has been studying communications between industrial research and development organizations and their sources of information about new technology. He noted that strong attention was given to the commercial sources of information. In the trade publications, both text and advertising were important to product-oriented people, but less so for the research-oriented people who tended more toward professional journals. There is a substantial difference in ways of communicating between the technologist and the scientist. The scientist is more apt to go to his colleagues, regardless of whom they work for, to discuss a problem. The technologist is more apt to go to suppliers who are the carriers of information on the technology "grapevine" of industry. Encouragement of formal publications is important because the writers are identified as appropriate people for informal communications. And, similarly, attendance at conferences enables one to evaluate the quality of a man's work from his presentation and personal conversation. But Gilmore notes that he found very little evidence of outside visiting scientists as guests at seminars in industrial organizations.

The importance of interaction between industry and university researchers, both in work and for continuing education, was emphasized by Allen, who cited the relationship between the Martin Company and the University of Denver, as well as that between the National Bureau of Standards and the University of Colorado. A number of Martin Company scientists are adjunct professors of the University of Denver. Short courses given at night or two-week summer courses were considered to be very valuable by people who had taken them.

A big obstacle to a lot of information communication is the matter of proprietary security, and the closer you get to a marketable product, the more the proprietary barriers spring up.

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Chapter III

The Social Psychology of Informal Communications Among Scientists *

Warren R. Graham
Albert Zavala **

The ways of scientists' interactions have been studied from several viewpoints in recent years, ranging from studies of creativity and innovation to their utilization of electro-mechanical information systems. The present study focuses attention on the social ways that scientists use to communicate technical information by personal interactions. It is one of a series of studies designed to examine the contributions of informal scientific communications to the advancement of science. At the outset we sought information about, and understanding of, the types, functions and problems underlying informal scientific communications. Assistance was obtained from a group of 107 Chairmen of university science departments, Directors of industrial laboratories, and Directors of laboratories of the federal government. The following questions were discussed with each person in the sample:

a. How do people in your discipline communicate scientific information <u>informally</u>?

b. What is important about <u>informal</u> scientific communications?

c. What are some problems of <u>informal</u> scientific communications?

d. How can <u>informal</u> scientific communications be improved?

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The sample of research leaders interviewed were employed by military and other government research institutes, university and industrial laboratories, and independent research organizations. They were drawn from the following disciplines: physics, chemistry, mathematics, physiology, microbiology, electronic engineering, and mechanical engineering. They were managers of research operations in 102 organizations of the following types:

Chemical manufacturing companies	6
Electronics manufacturing companies	7
Pharmaceutical manufacturing companies	5
Mechanical manufacturing companies	12
Military electro-mechanical laboratories	9
Military Environmental Medical Laboratory	1
Government, non-military laboratories:	
physics and engineering	3
oceanography	1
biology	2
Operations research consulting companies	4
Independent biological research laboratory	1
University-consortium national laboratories	2
University-managed physics-engineering institutes	10
University physics departments	6
University chemistry departments	10
University biology departments	7
University mathematics departments	5
University engineering schools	11

Informal scientific communications were defined as those communications that take place through personal interactions, either by oral or written means, excluding printed documents published for general dissemination. According to the response of our sample of research leaders, most scientists and research engineers transmit a substantial portion of their scientific information through informal channels. Their methods range from direct, personal conversations and phone calls, through meetings and conferences, to memoranda and preprints that describe completed research. Personal contacts include direct interpersonal communications between scientists, whether these interactions occur in the laboratory, at professional society meetings, or at small group conferences.

The important feature of informal communications contacts is that they involve person-to-person interactions.

Visits to Laboratories

It was recognized by research leaders that travel is a most important aid to communicating, because it provides direct contact with other researchers who are doing related work to that of the visitor. When universities invite people to give lectures, to interact with students and staff, and to visit laboratories, the direct contact is made in the host researcher's own environment. Traveling to make visits enables the scientist to acquire current information and to study equipment set-ups. Visits may include seminars, where scientists who attend can ask questions that might not be asked in a large group. Following a seminar, questions are asked personally that might not be asked for fear of appearing ignorant. Thus, the observations of leading scientists clearly indicate that social influences can affect a scientist's information exchange behavior.

Professional Society Meetings

The type of informal scientific communication situation that received a major share of the research leaders' comments was the national professional society meeting. At national technical meetings, papers are read and people meet with each other outside of paper sessions in the halls, coffee shops, cocktail lounges, etc. The following description of meeting behavior will begin with comments by leading researchers about papers; then the interpersonal contacts made among scientists will be discussed.

Attending meetings is considered to be important because the social interaction with other scientists serves to stimulate ideas. The papers show what a man is doing now, and they serve as advance notices of what will later be in the literature. Therefore, papers help with the future selection of important formal communications. Some scientists, however, felt that many papers are not sufficiently understandable. Others felt that the contents of papers usually were already known from other sources of informal communications. Some scientists recognized a trend toward increasing dependence on conversations, and remarked that presenting papers is becoming less and less important.

Thus, from the point of view of social communications interactions, convention papers are not considered to be critical by research leaders. The papers, they felt, are an excuse to meet with other scientsts who have common interests. It was recognized by some leading scientists that the value of meetings is not so much in the papers as it is in developing and maintaining acquaintances with people in one's own field to discuss scientific problems. Those who present papers are often guarded in what they say, but they will provide information not in their papers during private conversations. Gossip in the halls at meetings is a powerful means of information exchange. Many leading scientists felt that more real information is exchanged in the halls (lounges, coffee shops) than at paper-reading sessions. Another important advantage of large professional society meetings is that each individual scientist can meet and talk with many others from widely scattered places. One scientist noted that he made so many contacts at a single professional meeting that it saved his organization the costs of many trips during the year.

Important informal contacts with other scientists are built up at technical meetings. There one can talk to people in the forefront of a field and learn more about work being done in other laboratories. A scientist must get to meetings to talk to people who are doing things in his own field, because he might never be able to visit with them otherwise. The value of a meeting lies not in the papers, but rather in providing opportunities for maintaining acquaintances with people in one's own field, and in discussions of problems of mutual interest. Such contacts are highly fruitful, especially for young scientists, who learn whom to call upon for advice and information. Some research leaders consider paper-presentation to be a valuable training technique that stimulates young scientists to try to become better scientists. Meetings generally were seen as a means to revitalize all scientists who attend. They are motivated to do better work by an exchange of ideas and by stimulation of their sense of competitiveness.

Attendance at meetings held in foreign countries was frequently emphasized as being essential to enabling U. S. scientists to keep abreast of events that influence their disciplines. In addition, attendance at foreign meetings helps to clarify problems in technical translation of articles, and permits exchanges with foreign scientists whose governments will not permit them to send information to the United States by mail.

Scientific and Technical Conferences

It was noted that scientific societies are scheduling more specialized meetings at national gatherings, and the popularity of retreat-type conferences appears also to be on the increase. Small scientific conferences provide an atmosphere and an environment that stimulates free discussions of scientific problems, procedures and solutions. Such conferences are usually small (rarely over 100 persons) and attendance is by selective invitation. At small conferences the scientist finds opportunities to get to know others in his own field of specialization. A major part of his time at conferences is spent in technical discussions and conversations.

Retreat conferences enable scientists to become acquainted with leaders, and contacts are made that can be kept up over the years. It is said to be highly valuable to attend conferences where members live together for a week or so, especially if specialists are of the same kind. Thus, friendships are deemed to be highly important for effective information communication. For example:

One can discuss matters in pre-proposal stages with a friend without concern for preserving the integrity of ideas, and can get more honest answers to questions than might be forthcoming from a stranger. Asking a friend what is new is a valuable way to acquire information. When you know a person quite well, the flow of ideas and information comes freely. Some scientists are especially cautious in sharing ideas with newcomers who may publish their ideas, good or bad, without getting permission beforehand. Dealing with a friend may produce better information exchange than professional dealings.

Researchers hold many different types of conferences ranging from periodic local dinner gatherings of small groups of specialists to week-long invitational conferences, conducted on a national scale. The most frequently mentioned retreat-conference is the Gordon Research Conferences, each of which lasts for one week . They are held at residential colleges in New Hampshire during the summer months. There specialized topics of interest to research chemists are discussed in depth. Other such conferences are The Summer Community of Scholars (Plattsburgh, New York), the Josiah Macy Conference, the Woods Hole Conferences, the Brookhaven Symposia, and conferences held by universities (such as Harvard, Columbia, and Virginia).

Smaller groups also meet periodically, such as The Baltimore-Washington Enzyme Club, the Adrenal Physiology Dinner Group, and the Nuclear Magnetic Resonance Conference.

Some universities give short summer courses on specific topics where scientists are able to live together. Such specialized lecture meetings and refresher courses serve to broaden the background and experiences of researchers. They also serve to stimulate technical discussions and conversations in the same way that scientific conferences do.

Telephone Conversations

Telephone calls and letters are a major means to have a dialogue on an idea, but letters are considered to be a primary source of information, especially when they enclose memoranda. The telephone is considered to be one of the best means of communicating, and the expense is not deemed important when critical problems are involved. When a new problem comes up a telephone call can produce required information in a few minutes that could otherwise take days of library research. A telephone call often will settle a technical letter of inquiry that otherwise might be passed from person to person at much waste of time. Where a consulting service is offered, the telephone is used for most such communications. In such cases letters are usually used to confirm what was said on the telephone.

Some scientists recognized that the phone is an important channel of informal communication in spite of the fact they rarely used it. Others recognized that the long distance bill is high at their institution. Many prefer to call rather than write since it would take three times as long to obtain information without the telephone. Other scientists compared the use of the telephone with travel. Travel is considered to be the most important aid to communication because there is direct contact with other researchers. Telephone conversations are considered to be substantially less useful than travel, but many felt that the video telephone will make telephoning almost as valuable as visiting.

Generation of Ideas

Meetings bring forth information that leads to research ideas, and many scientists go to the meetings to meet specific persons who are working on problems of mutual interest. Attending meetings, listening to papers, lectures, and seminars serve as stimuli to start ideas generating. Papers read at meetings can be sources of information that provide ideas to be applied to other purposes. Scientists get many of their ideas when they explain something to a colleague who can understand what is being discussed. An exchange of ideas as well as of information is necessary to keep abreast of recent developments.

Oftentimes we cannot help but communicate informally; it comes naturally. It gives a person reinforcement on his own thinking. He may get an immediate answer to a problem or he may try out something to see if it will be shot down. Informal communication allows one specialist to help another to do things neither could do alone. Progress derives from asking critical questions and stating a concept or a point of view which could not easily be done through formalized, edited, and reviewed publications. In the free asking of such questions, the delineation of concepts or points of view result from the direct interaction of more than the one mind. Also, a scientist can not always find a colleague at his own institution who is interested in his particular specialty. Therefore, he attends meetings or employs other channels of informal communication in order to interact with such colleagues. Such exchanges of ideas with other competent researchers can aid a man who is blocked on solving a research problem.

Personality

In many cases the personality of the researcher becomes involved in his informal scientific communications. Some would rather not talk about their work until it is completed. It should be noted, therefore, that what one hears in the informal channels may not necessarily be what is best; rather, one may hear only about what is being done by more talkative people. It was said that the more gregarious one is, the more likely he is to pick up information. Certain scientists have gained eminence in their fields, not so much through the publications that they have authored, but rather through the fact that they were gregarious people and had developed many acquaintances. It also was observed that theorists appear to have a greater need for informal communications than experimentalists. Theorists seem to need colleagues as a "sounding board" more often than others do.

For example, in particle physics, the more speculative the ideas are the more communication is said to be done by informal means, because personal barriers can be let down.

It has already been mentioned that a considerable amount of information is exchanged between scientists over a glass of beer in bars or cocktail lounges. One scientist observed that many women scientists might not feel comfortable among men who are talking in a tavern. In contrast, other scientists felt that whether or not a woman felt left out of conversations depended on the woman herself. But many women scientists do not recognize such matters as a problem. This does, however, point to the likelihood that certain scientists might not be within the mainstream of informal channels of communication, particularly where communications of the face-to-face type are concerned.

A person cannot easily transmit his impressions and emotional commitments to an idea by using formal means of communication. Such personal commitments are important to scientists. It was said that there is much to be gained from the reactions of others with whom one communicates about science. A direct answer to a question or idea may not be forthcoming, but a raised eyebrow or a narrow squint can indicate an emotional response that is important.

Sociological Considerations

The sociology of research communication through meetings, conferences, and refresher courses can be expanded to include the influences of organization and community structures. In some large organizations that are structured with multiplicity of divisions, there are special communications problems. The centralized research divisions of certain industrial organizations often provide technological advice and service to the other divisions of the company. Communications difficulties in terms of awareness of problems are great for such research divisions. Other organizations have a research department in each division, and communication blocks between departments or divisions may be generated by competition among them based on vested interests. A number of research executives recognized that too much formalization of communication can cost an organization its growth. They indicated that they encouraged informal, intergroup communication which, in turn, encourages interdisciplinary research.

Cultural Considerations

In certain instances the structure and composition of the community in which a scientist lives can influence his exchange of scientific information. As activity grows around a university or group of research laboratories, extra-mural groups emerge consisting of students, researchers, professors, former professors, etc. The resulting research community spreads throughout the area and becomes an important basis for information exchange. Once a pattern of exchange is started, it is said to continue even though there may be some circumspectness. Excellent examples of such "spin-off"communities were described to exist around universities such as MIT, Harvard, Stanford, and Chicago.

Scientists often take for granted the various channels of informal communication which are at their disposal. One scientist related that when he was in Central and South America, it was difficult to get things done because the channels of communication were so bad. The telephone service was poor and the rail and airlines were unreliable, which meant that it was difficult to communicate by mail. In some countries the highway communications are also bad due to the lack of vehicles, as well as to the lack of adequate road networks. Such a situation, of course, does not apply to some of the well-known population centers. Foreign customs also can create problems in informal communications. For example, as a matter of politeness, the Japanese say "yes" when they mean "no." This leads to confusion, unless this custom is understood. And translation problems are common when U.S. scientists visit Europe and Asia. One scientist who had traveled frequently to Europe indicated that a number of his European colleagues had independently said to him to the effect: "You are always on a trip or on the phone. Americans are very mobile and informal. We Europeans write letters and go to meetings, but we are more formal about these things. You Americans, therefore, make more rapid advances and strides in science."

<u>Timeliness and Clarification</u>

Timeliness of information is an important consideration, often brought up in discussions of informal scientific communications. It was observed that the pace of current scientific progress makes formal communications less important than previously. Some rapidly changing research areas are such that last year's data may now be obsolete. The most recently published material can be too old in other disciplines. The exchange of information and ideas through informal communication is, therefore, necessary to keep abreast of recent developments. Informal channels serve as a time-saving device by which one can get information sooner than otherwise. It also was mentioned that informal channels are especially valuable because they can provide information on negative results which are not usually published. Having such information available reduces the probability that the scientist will repeat a useless experiment.

Clarity concerning research interpretation is obtained informally because it is possible to learn more details than are published in technical articles and reports. The informal mode also allows a poor writer to get his message across because when the inquiring researcher does not understand a point, he can ask for a clarification and obtain it virtually immediately.

<u>Other Types of Informal Communications</u>

Proposal readers and members of planning advisory staffs of fund-granting organizations frequently obtain knowledge of planned research far in advance of others in their scientific disciplines. Editors are often ahead of formal communications, as are those who screen abstracts of papers for professional society meetings.

Vendors supply much useful technical information informally, but the quality of their informal information sometimes is questionable. Consultants quickly can bring scientists up-to-date in their knowledge, but consulting requires much time and is expensive. Some scientists ask for references to specialists as well as for references to literature. Certain specialists are used as sources of information. Since it is impossible for a scientist to read everything that is published in his field, a scientist must depend on colleagues for leads as to what is worth reading. Therefore, we conclude that informal channels serve as an efficient means of information retrieval.

Summary and Discussion

The various methods of communication among scientists cannot be completely bifurcated into formal versus informal. It would be more realistic to recognize a series of steps (or a continuum) going from the informal to the formal, with a parallel series or continuum going from the biological to the mechanical means of information storage and retrieval. These continua are reflected in the various channels of communication, such as direct personal contacts, meetings, telephone calls, letters, preprints and publications. Individual and social influences are inextricably entwined in the various methods of communication, and their interaction plays an important role in scientific progress.

It can be deduced from the comments of research leaders that there also is an important relationship between communication in science and socio-cultural variables (e. g., group cohesion, social reinforcement, group structure, community organization). There also is an apparent relationship between personality variables and scientific communications behavior. It is expected that future intensive studies of the communications behavior of scientists will serve to clarify the importance and strength of many of the hypothesized relationships that the research leaders have pointed out.

Chapter IV

Research Managers' Suggestions on Problems of Informal Scientific Communications*

Albert Zavala
Warren R. Graham **

For more than two decades research has been conducted on problems associated with the exponential increase of scientific literature. A number of computer-based information storage and retrieval systems have been proposed, and some have already been built. But problems of information acquisition in science are still relatively unsolved. One notion frequently expressed in studies concerning formal information systems and user-needs is that informal scientific communication plays an important role in scientists' information transfer. Emphasis also has been placed on the concept of the "invisible college," which was popularized as a focus of discussions of informal scientific communications. Our exploration of the social and psychological aspects of scientists' communications behavior, however, suggests that their problems extend far beyond the restricted information exchanges that occur within such unstructured groups.

"Informal" scientific and technical communications are defined for the purpose of this study to include oral communications, such as lectures, discussions, telephone conversations, technical meetings, and social gatherings. Also included are written memoranda, proposals, and pre-publication papers. Thus, informal communications are those that involve person-to-person interactions. Formal publications designed for mass dissemination of scientific and technical information are excluded.

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The principal problem we have had under investigation is: How can we characterize what is happening among scientists and engineers with respect to informal scientific and technical communication? We are attempting to explore and to define the role, nature, and boundaries of informal scientific and technical communications, and the conditions under which informal communications are used to advance research efforts, including their relationships to formal channels of communication. Evidence is being accumulated concerning the motivational, informational, and innovational influences of informal technical communication on the professional behavior of research scientists and engineers.

Our aim is to explore the nature of all types of informal scientific communications behavior in a wide variety of situations. It is an effort to learn more about highly unusual types of informal technical communications, as well as about those that are relatively commonplace. The primary emphasis is on exploring to identify the diversity of informal communications problems, rather than to establish their frequencies of occurrence. Generalizations to the behavior of the national population of scientists and engineers can be made on the basis of later studies, after the facts, problems, and functions of informal scientific communications become better known.

There are obviously many ways that scientists communicate informally about their work. But little is known about the variety, frequency, and importance of such contacts. One way to acquire a better understanding of how and why scientists communicate informally is to question highly experienced and successful scientists about it. This report is a montage constructed from 107 informal discussions with Chairmen of Departments at universities, and with Directors of Research at government (military and non-military), industrial, and ind pendent laboratories. The research leaders who assisted us were drawn from a number of disciplines, as follows:

(a) Physics, (b) Chemistry, (c) Biology, (d) Mathematics, and (e) Engineering. The laboratories that employed them are in areas heavily populated with research organizations in the eastern third of the United States, including: (a) Chicago, (b) Buffalo-Rochester, (c) Boston, (d) New London-Bridgeport-Hartford, (e) Long Island, (f) New Jersey, (g) Baltimore, (h) Philadelphia, and (i) Washington-Maryland-Virginia. We visited 102 organizations of the following types:

Chemical manufacturing companies	6
Electronics manufacturing companies	7
Pharmaceutical manufacturing companies	5
Mechanics manufacturing companies	12
Military Electro-Mechanical laboratories	9
Military Environmental Medicine laboratory	1
Government, Non-Military laboratories:	
Physics and Engineering	3
Oceanography	1
Biology	2
Operations Research Consulting Companies	4
Independent Biological Research Laboratory	1
University Managed Physics-Engineering Institutes	10
University-Consortium National Laboratories	2
University Physics Departments	6
University Chemistry Departments	10
University Biology Departments	7
University Mathematics Department	5
University Engineering Schools	11

Our discussions centered around the following broad questions:

a. How do people in your discipline communicate scientific information <u>informally</u>?

b. What is important about <u>informal</u> scientific communications?

c. What are some problems of <u>informal</u> scientific communications?

d. How can <u>informal</u> scientific communications be improved?

The nature, advantages and disadvantages of using various informal means of communicating are presented below, followed by the suggestions that were made for improving communications within each informal channel.

Professional Society Meetings

Meetings constitute an economical means to information-exchange with scientists that one might never be able to visit. Here the scientist learns of research that others are doing in his field of interest, obtains details about current work, and exchanges information and ideas with respected colleagues. Contacts made at conventions are especially valuable for young scientists, who gradually learn whom to call on for information and advice. Meetings also bring information that leads to new ideas and motivation to put them to the test of research.

The size of meetings was regarded as important with respect to informal information exchange. It was felt that communication is best accomplished at small informal meetings, such as regional professional society meetings, which usually are smaller than national meetings. The advantages of regional meetings were given as lessening of travel time, lowering costs, and increasing control over the size of meetings, so that longer talks and more time for discussions can be allowed.

While many advantages of professional society meetings were brought out, disadvantages were also mentioned. For example, while some leading scientists felt that at the first few meetings they got to meet new people, and got the feel of various specialties, this did not necessarily hold later on. With respect to obtaining information through the give-and-take personal contacts, it was frequently said that one could not always trust the reliability of information passed through a human memory. A number of our interviewees mentioned that many professional society meetings are held in competition with one another, and are scheduled so as to overlap in time. Others noted that an "in-group" tends to take over presentations at meetings, thereby controlling what can be presented. Also, complaints were voiced that there is a tendency to fail to tailor discussions or talks to the expected audience. As to the presentation of papers, many research managers considered it to be absurd that papers were accepted on the basis of abstracts alone. It also was felt that the contents of most convention papers were already "old hat" to those knowledgeable in the field. Many specialists felt that they rarely heard papers that they had not already learned of through informal channels. Many of leading scientists we interviewed felt that papers are becoming less important and that talking with people is becoming more important as a convention information source.

Costs often were mentioned as a disadvantage of professional society meetings. While universities frequently do allow some money for travel, it usually is not sufficient to cover all necessary expenses. Some scientists noted with misgivings that the National Science Foundation now does not provide money in research grants to cover attendance at meetings. It was pointed out that experienced researchers do not go to meetings as tourists, because there is no longer any novelty in it. On the contrary, a number of leading research directors said that they meet many colleagues at professional society meetings and that this opportunity to meet saves the expenses for several costly trips each year.

Suggestions regarding professional society meetings revolved principally around three topics, conduct of the meetings, group size, and costs. A need was recognized for improvement of the design and conduct of meetings of all types. It was suggested that panel leaders need training in conference leadership and agenda preparation, and that a foreceful discussion leader of prominence is needed to carry out purposes of a meeting. It was suggested that paper-session chairmen should send copies of papers to others who will come to listen with the request that they stimulate discussion by asking relevant questions of the authors. Another suggestion was that societies should leave the last hour of the day for open meetings for those who want to come and talk about their work. This is only one way to meet the desire for more encouragement of spontaneous presentations by providing a place for those who wish to speak extemporaneously.

Suggestions as to the size of meetings favored those small in size. It was advocated that an increased trend toward symposia should be encouraged in order to bring together those with common interests and to stimulate interaction between panel members and audience. Most leading scientists favored small, intimate meetings which are selective and provide a great opportunity for informal exchange between individuals. Several scientists said that they would not go to a meeting where there was no chance to share ideas with others. The upper limit of the size of a small meeting was most often placed between one and two hundred. One suggestion for increasing the number of small meetings was to encourage regional meetings. The encouragement of regional meetings was advocated by some, not only for the sake of small group size, but also to lessen travel time and decrease costs. It frequently was indicated that more money is needed for travel to conventions. This need applied to private industrial and government laboratories as well as to university departments. It was suggested that scientists should attend a minimum of one meeting per year, and that they should be encouraged to submit papers. However, a scientist's attendance at meetings should be supported even when no paper is given, because personal contacts are so important. One leader estimated that although about 10 percent of scientists might use meetings only for recreation purposes, the majority benefit.

Research Conferences

One point frequently made regarding informal scientific discussions was that more and more they are dealing with specific subjects in some small field. Groups are often formed just to meet and discuss topics in a small specialty area. The increasing size of professional society meetings, the trend toward smaller groups, and difficulties regarding paper reading sessions all appear to have led to the increasing popularity of retreat-type conferences. Of these, the Gordon Research Conference is undoubtedly the most widely known and it is considered to be among the most valuable and effective. Speakers present information informally in the morning, with afternoons free, and other speakers during the evenings of a one-week period. A unique rule of the Gordon Conference states that whatever is said is not for quotation or publication. This rule permits a free exchange for building and challenging ideas.

Retreat conferences, discussion, or dinner groups were declared by many research leaders to be very useful and profitable in terms of stimulating ideas and exchanges of valuable information. Also, it was generally agreed that it is highly valuable to attend conferences where members live together for a week or so, particularly if the specialists are in the same area of interest. One thus becomes acquainted with leading researchers in his own field of interest, and these contacts can be kept up over the years. An atmosphere and environment is provided at such conferences where the details of science can be discussed with freedom. But if only experts are invited to conferences, the chances for valuable communication are high.

Some of the disadvantages of these conferences stemmed directly from their advantages. For example, one feature of retreat-type conferences is that they are held in out-of-the-way places and that some scientists feel guilty about taking time off to attend. When attendance is by invitation only, the meetings usually are restricted to experts, and the young scientist, who might have a great potential for contributing to the field, does not have an opportunity to profit from attending. Yet, some people were said to be invited solely on the basis of their contacts. In addition, because the conference groups are small, the range of dissemination of information is limited. Also, travel and sustenance money is needed to attend these meetings, and this can be an expensive proposition. Further, some scientists may not be informed about when or where a conference is being held.

Among the suggestions with regard to conferences was one to the effect that employing organizations should encourage attendance at these meetings by helping to defray the costs involved. Another suggestion was that there should be greater participation on the part of research sponsors to support research conferences. It was also suggested that more effort and planning should go into these meetings. In this way more specific and valuable information is exchanged. Another suggestion was to increase the overall number of these meetings to keep them small, while at the same time providing opportunities for more people to attend. Other suggestions relating to the need for more specialists' conferences relate to short university courses and to dinner groups. Short courses of several weeks' duration were seen as serving about the same purpose as retreat conferences, if they are restricted to up-dating scientists in particular specialties. And during the course of a year's time, the monthly meetings of an informal dinner-discussion group also was advocated to fulfill the same purpose on the local level.

Visits

J. Robert Oppenheimer is said to have remarked, "If you really want to communicate, send a man." This statement exemplifies another important channel of informal communication, which consists of visits made to other laboratories. University science departments often invite professors from other universities to their laboratories. Likewise, government and industry laboratories sometimes invite scientists in the same manner as do universities. These visits usually include an informal talk by the visitor at a seminar and later discussions with staff members. The visits usually include a tour of the laboratory facilities, which are useful and instructive to the visitor, since he can compare equipment set-ups. In this process there is a give-and-take, where the visitor gives information by way of the seminar, and exchanges other information through discussions.

Scientists travel more now than they used to, and they exploit the time saved with rapid transportation to visit more colleagues. It is quite common for scientists to go across the country to look into some special problem that has arisen (e. g., to select equipment, to discuss a problem, or to visit laboratories to learn what they are doing). The resulting benefits can be unexpected. For example, a scientist in the East traveled to Stanford University, California, for a scheduled conference and, incidentally, visited a friend while there. From his incidental visit he learned about and was given several computer programs worth far more than the cost of the trip.

One scientist who traveled frequently to Europe indicated that a number of his European colleagues had independently said to him in effect: "You are always on a trip or on the phone. Americans are very mobile and informal. We Europeans write letters and go to meetings, but we are more formal about these things. You Americans, therefore, make more rapid advances and strides in science."

There are certain difficulties associated with visits. Some scientists felt that informal visits to other laboratories exceeded the benefits obtained, because the half-day or full-day visits take up a great deal of time, and they are costly. For the same reason, many laboratories have established policies restricting the amount of visitors coming into the laboratory. In many laboratories, approval is required for traveling either to conferences or to visit other laboratories. Scientists at these laboratories often become discouraged and do not even ask to go. On the other hand, most government scientists are required to travel to government conferences and to visit other government laboratories. This means that the government may be fooling itself about cost-cutting with regard to travel expenses.

Suggestions about visits centered around increasing the opportunity for mobility of scientists. For example, it was suggested that scientists need freer opportunities to make informal contacts with other laboratories and institutions. To implement this, management should encourage more mobility of scientists and should encourage more visitors to participate in staff discussions. One suggestion was to follow the lead of the American Institute of Physics which arranges visits by scientists to small colleges and universities to bring them advanced information to up-date their faculties and students. Another suggestion was to prepare video-taped visits to various laboratories based on questions and demonstrations made during actual visits. The tapes then could be distributed to other institutions for the benefit of their staffs. Another suggestion was that scientists at one laboratory should be permitted to perform special work at another laboratory that has equipment and facilities uniquely suited to the special work. The expense of travel and subsistence could be less costly than purchasing special equipment.

Telephone

Telephone calls were recognized as a major means to have a dialogue on an idea. A telephone call can immediately settle a letter of inquiry that might otherwise be passed through many hands at much waste of time. Use of the telephone is particularly advantageous in an area of concentration of research activity, such as Boston, Chicago, New Jersey, Palo Alto or Washington. Also, when a problem arises, one often can call someone else and get information in a few minutes that might otherwise take days of reading in a library, searching for information. In fact, the people at many laboratories stated that they did not hesitate to make long distance calls to obtain scientific information. In scientific consulting, the telephone is useful for many communications, and these can be followed up by letter or telegram to confirm telephone conversations if necessary.

Although travel was generally conceded to be the most important aid to communication, because there is direct contact with other researchers, phoning was considered to be next most useful. Many scientists recognized that their long distance bills were high, and that this was of concern to administrators who did not always figure the savings that can evolve from a phone call. Another difficulty is that telephones are often overloaded, which is frustrating and may reduce efforts to obtain information. The principal suggestions on the use of the telephone centered on increasing its use and efficiency. It was suggested that managers need to be more liberal about the use of the telephone, since phone calls can save travel money and enable problems to be solved quickly.

Mail

Most leading scientists write a lot of letters about science and frequently they involve the exchange of unpublished material. Letters are considered by many research leaders to be a primary source of scientific information, and some considered them particularly important when they include research memoranda. Letters sometimes appear as references to personal communications in the literature. However, letters are considered too slow for formative efforts in research, and it is considered more difficult to express oneself in a letter than in a conversation. Moreover, some scientists felt that letter writing was limited because many delay answering or do not answer their mail at all.

Preprints

Though a preprint may be a copy of an address or a lecture, most often it is essentially a copy of a paper submitted, or to be submitted, for publication. Many preprints thus wind up in print and become part of formal communication. In some cases the sending of preprints exceeds the distribution of reprints. Some research leaders indicated that few scientists read journal articles anymore, because they already know about the results from preprints. The principal modern purpose of preprints appears to be to circumvent long publication lag-times. Another use is to report partial results of an experiment that might take years to complete. Preprints are stimulating, and some leading scientists believed that more significant information got into them than into journal articles, because formal, editorial requirements are not imposed.

It was recognized by many research leaders that there are disadvantages to the use of preprints. First, the output of preprints has grown beyond a reasonable level; there are so many preprints now that one cannot read them all. Another disadvantage of preprints is that they may propagate erroneous conceptualizations based on shoddy work. Also preprints too often go to those known to be interested, but not necessarily to those who may benefit. As a result, a capable young scientist may fall from six months to a year behind in his field. In addition, it becomes expensive to send preprints to a long list of scientists.

Suggestions regarding preprint problems focused on reducing their number and facilitating their distribution. For example, it was suggested that the preprint should not be abolished since there is much to be gained from it. It also was suggested that letters to the editor and short technical notes no longer should be placed into the preprint system, since such items do not typically have long publication lags. It was also suggested that review articles and theoretical articles not be distributed to preprint lists because such articles retain their timeliness in spite of publication lags. Preprint distribution costs can be reduced by sending preprints out periodically rather than continually. A further suggestion was that preprints should be sent to organizations rather than to individuals, allowing the organization to duplicate them for intra-organization distribution. In this way, part of the cost of distribution is passed on to those who benefit from the preprints, the receivers. The Information Exchange Group (I. E. G.), sponsored by NIH, has been discontinued because it often was used as a medium of publication. Continuation of the I. E. G., with needed reforms, was suggested.

Consulting

Consulting is another channel of communication of the informal variety. Consultants receive and convey a great deal of information informally. When a laboratory brings in a consultant, his contributions can be very great provided that the organization can formulate a problem and choose a consultant from the appropriate specialty. Consultants also can be used to bring scientists up to date in their knowledge. Some firms use consultants to assist those on their staff who want to go into new areas of research. Sometimes the consultant can act as a catalyzing agent for creative thinking, which can lead to the solution of the problem at hand. Some laboratories send consultants the world over, and their acquired knowledge is conveyed to staff scientists for future use.

Problems of National Security

It was noted that security requirements hinder scientific communication, because it restricts one from t[illegible] others about unique developments and new knowledge. Moreover, security considerations hamper the explanation of why certain questions are being asked. Such restrictions reduce informal scientific contacts and create delays in receiving documents that are classified. Sometimes classified information necessary for a project is received after the project has been completed. Classified information inhibits discussion with outside sources to solve problems, but although classification of information delays communication, it does not prevent it. Security requirements tend to slow down progress of scientists who are trying to produce things to preserve the national security by keeping ahead of potential enemies. We need to expedite the interchange of classified information to allow scientists and engineers to work more efficiently. It was remarked that if a conference is announced as "classified," then you get good attendance, but not if it is announced as "unclassified," because people feel that unclassified information can't be very good.

The age and experience of persons engaged with work involving classified information was mentioned as a factor that is associated with attitudes about it. A feeling that one is left out of the "know" and can't learn about things that he should be aware of is quite prevalent. But older scientists who are experienced with security matters are much less concerned than are younger men.

Managers, it was reported, sometimes are not permitted to know the nature of secret work being done by their subordinates, even though the managers are cleared at a suitable security level. Also, if one must go to an agency different from the project sponsor for classified information, often it cannot be obtained because cross-service acceptances of security clearances are limited.

One research leader noted a need for consistency in defining classification categories, and in maintaining the definitions which were given. For example: One organization was said to have two projects on the same problem. One project was being done for NASA and the other one for the military. One project was classified; the other was not. It was also stated that on occasion certain papers become classified information if they are prepared under a military contract, but not if they are written on company time.

The tendency to be over-safe about security matters can be very limiting to scientific communication, and it was noted that over-classification of information frequently occurs. The free flow of scientific information is limited by a "need-to-know" for classified information, and a price was said to be paid in technical progress due to this requirement. Highly classified material is sometimes hard to get. Even large university laboratories under military contract were said to have difficulties because a "need-to-know" for classified data causes a loss of time in contacting government people to get classified information. But many responsible scientists apparently do not know how to best proceed to get the classified information that they need.

Reviewing scientific papers before publication is a means of informal communication. But administrative regulations requiring review at several levels by non-te hnical people for security purposes was not considered to be efficient. Fr ently, technical classified information cannot be interpreted by the non-technical people who are responsible for security reviews. This was said to make the security reviews a waste of time. Another complaint was that peripheral knowledge often is classified without necessity. Some laboratory heads felt that more self-discipline is needed when classifying information in order to define more sharply what should be classified, and the remainder should be published as contributions to general knowledge.

A number of suggestions were offered to alleviate constraints imposed by security classification requirements. In order to supply scientists and engineers with classified information they require to keep their knowledge up to date, more classified conferences were suggested. One example that was given is the Military Operations Research Symposium of the Office of Naval Research. Another example, now discontinued, was the "Open House" at Langley Field, where new developments and equipment were presented to cleared members of the research community.

The facility with which "need-to-know" can be established was thought to be subject to improvement by the following means:

a. Develop a security system that is common to all military services.

b. Provide each cleared key person with a "need-to-know" statement for the specialty he works in.

c. Develop a computerized central clearing house system to provide a monthly listing of cleared persons.

The fact that many responsible scientists are not adequately informed about how to establish "need-to-know" suggests that a briefing suitable for such audiences needs to be developed and used for instructional purposes.

Over-classification of scientific and technical information is a continuing problem for scientists and engineers. In order to keep the number of classified documents and projects at a minimum, it was suggested that only persons of high technical training should be used to determine security levels for new information, and to declassify older documents that contain information generally known to science.

Proprietary Interest Problems

Proprietary interests create problems similar to those caused by the need for classification of security information. Certain scientists are bound by their companies not to communicate proprietary ideas at conferences, meetings or otherwise. Thus, when industrial and academic scientists gather, the academic group often is disturbed by the lack of information forthcoming from industrial scientists. Industrial scientists admit that the breakdown in communication is caused by their need to be constrained in informal situations. Some research scientists and engineers appear to be hesitant to discuss their ideas (whether good or poor) because they are afraid someone might steal them or publish them without permission. Concern about theft of ideas, therefore, can create serious barriers to communication of scientific information.

Some cliques, it was noted, have been known to maintain a security classification on information even though it was not required. Their purpose, apparently, was to remain as sole investigators in a specific research area. It was also mentioned that university scientists, as well as those in industry, develop cliques that retain information to themselves, and that this often caused duplication of efforts. One leading scientist pointed out that research supervisors often tend to withhold information that they acquire at management meetings.

Competitive bidding for a sponsorship sometimes causes a withholding of ideas, as does the need for credit for a publication, or waiting for a product to appear on the market. Even in universities, it was said, scientists sometimes refrain from talking about their work in order to get a research done first and to get the credit and associated rewards. Thus, informal communications do not necessarily give immediate feedback, since considerable amounts of information may be withheld.

A number of suggestions were offered to reduce proprietary restrictions. For example, in certain industries (e. g., chemical) competitors would not be asked for technical information, whereas in other industries (e. g., electronics) information is exchanged freely and frequently. A possible solution for other industries is to encourage cross-licensing, such as exists in the electronics industry.

Although competitive bidding may be the most effective method of letting contracts for production of materials, equipment, and many services, research and development efforts may be enhanced, and scientific communication improved, by direct placement of design and development contracts based on judgments of impartial panels of technical experts. The emphasis on the "publish-or-perish" concept can be reduced by developing better methods of evaluating scientific productivity. The result could well be a reduction in trivial research publications and freer, more effective informal exchange of information and ideas.

Problems with Contracting Administrators

Many communications problems arise in dealing with contracting personnel who do not understand the nature of scientific work and how it is done. For example, it is very difficult to explain to a non-scientist why progress is slowed due to a lull in the production of new ideas. But communications problems can also occur with scientist-administrators who have lost close touch with their fields and who no longer identify with the problems of science and researchers.

Suggested remedies were that sponsors who do not have representatives who are highly technically qualified should employ impartial consultants from university or other non-profit institutions, such as the Institute for Defense Analysis, and wherever possible, sponsors should use only monitors who have been educated to understand technical problems and trained to understand the creative process.

To conclude, in discussing the various channels of informal communication perceived to exist by leading scientists, it becomes apparent that there is no hard and fast line between the formal and informal modes of information transfer. It is also evident that scientists pursue one or another of the informal channels of communication to overcome time lags and to obtain feedback with respect to the ideas they pass on to others; again, preferring to avoid delays in feedback. With regard to suggestions and recommendations, most scientists made suggestions that would increase the opportunity for the informal exchange of scientific information. Many of these suggestions built upon existing informal channels and called for additional funds to boost their use.

The most important part of the work reported here, however, appears to lie in the specificiation of available channels of informal communication. Delineation of research ideas and suggestions for improvements, which for many scientists would otherwise have remained implicit, also are important. In the future, channels of informal communication may be more frequently and efficiently used, and they may be examined more thoroughly in future studies. But, it should be noted, to exploit informal communication channels is not to formalize them.

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Chapter V

Informal Scientific and Technological Communications Behavior of Researchers*

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The study described below was undertaken to explore intensively the types, functions, and facts of informal scientific and technological communications among scientists and engineers. It was specifically designed to describe how scientific and engineering research personnel go about the daily business of generating new knowledge and developing new materials and equipment. "Informal communications" were defined for the purposes of this study as those communications that involve personal interactions. Publications produced for public dissemination of information were excluded. This study is concerned only with informal scientific and technological communications behavior.

The general purposes of scientific and technological communication are: (1) to develop awareness of a problem, (2) to develop ideas about how to solve the problem, (3) to develop a research or development plan, and (4) to communicate current information to further basic research, education, and applications. Informal scientific and technological communications can be described as fulfilling several special functions: (1) to obtain details of research designs, procedures, equipment, formulas, and equations, (2) to obtain

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unpublished results, solutions, knowledge of failures, and data, and (3) to develop greater understanding of events through discussions of problems, ideas, interpretations, theories, and facts (including information about other disciplines).

The area of informal scientific and technical communications behavior is highly complex and diverse, covering many different types of personnel (both scientific and engineering), in many different organizations (both very large and very small), and in many locations (both isolated and urban). This study was purposely designed to obtain information about scientists and engineers based on their own experiences. It is an attempt to explore and to define the nature, roles, boundaries and conditions of informal communications which serve to enhance research efforts. The aim, therefore, is to investigate all possible types of informal scientific communications behavior in a wide variety of situations. It is an effort to learn more about highly unusual modes of informal communication, as well as about relatively commonplace ones. Thus, the primary emphasis is on identification of the greatest possible diversity of communications problems and suggested solutions, rather than on the mere establishment of their relative frequencies of occurrence. It is intended that generalizations to the behaviors of national populations of scientists and engineers should be made on the basis of future studies that are specifically designed to provide information suitable for supporting generalizations.

Procedure

In order to obtain information about the informal communications experience of scientists and engineers, a standard interview was developed on the basis of previous user-need studies that had incidentally accumulated some information about informal scientific communication. Background discussions also were held with approximately 40 directors of research and chairmen of university science departments in a variety of disciplines in order to develop a preliminary group of questions. The first draft of the interview was administered to six research psychologists who critiqued the procedure and recommended revisions. The final interview contained 20 questions directly relevant to the generation and uses of informal scientific communications and five questions on interpersonal communications contacts of interviewees with others in their own organizations. During the field administration of the final standard interview, all questions and responses were tape-recorded by trained interviewers.

A letter containing a description of the project and a request for an interview was mailed to each of the potential participants. The letter was followed by a telephone call from an interviewer. The interviewer visited each participant, equipped with a tape-recorded briefing about the project. After playing of the briefing tape, the interviewer answered whatever questions were asked. The briefing presentation was closed with the statement that the project offered a unique opportunity for scientists and engineers to make known their problems and needs in the area of informal scientific and technical communication. Following the briefing the interviewer tape-recorded the standard interview (approximately one-hour duration). The tape-recorded interviews, in turn, were evaluated by a content analysis based on coded information that they contained. Questions which provided additional information that could not be coded were transcribed verbatim for later qualitative analysis. Thus, two types of content analyses were made of the tape recordings: (1) a frequency count of coded responses to the interview questions, and (2) a summary of the important semantic contents of general relevance to understanding and improving informal scientific communications of scientists and engineers.

Sample

The possibility of searching through directories of professional societies that contain over a million entries for active researchers was an insurmountable task for this project. Therefore, it was decided to limit the number of disciplines and organizations that would be explored by selecting them for the following reasons:

1. To investigate the communications behaviors of scientists from the disciplines of chemistry, physics, biology and mathematics, and engineers in the major functional technological classifications (i. e., mechanical, electrical).

2. To permit identification of possible differences of problems and behavior between different types of organizations, such as industrial, university, independent, and government laboratories.

Consideration of the ways in which we could explore informal communications behavior made it apparent from the beginning that we would need to use volunteers. It also was apparent that we would need to identify participants by asking research directors and department chairmen to recommend researchers in their organizations whom we could ask to assist with this study. It also was necessary to inform managements of the nature of our operation in order to prevent misunderstandings about our purposes, especially at laboratories involved in operations concerning proprietary or national security.

It was considered necessary to study a variety of scientific disciplines, types of organizations, and geographic locations and an attempt was made to maximize diversity within small groups. Thus, our sampling procedure was designed to allow us to determine the nature of informal scientific and technical communication behaviors in a wide variety of locations, disciplines, organizations, and situations.

The exploratory nature of the study, and its emphasis on developing methods to study informal scientific communications, did not demand representative samples. In any event, a sample of people that is randomly selected at the beginning of a study will not necessarily provide a random sample when the data are tabulated. Experience has often shown that many individuals in a random sample will not cooperate, and a considerable percentage will drop out for other reasons. The net effect of such attrition usually is to introduce bias into a human sample.

In order to identify the participants required, a sample of research organizations was selected. Those that were chosen gave promise of providing sufficient numbers of scientists and engineers in the desired disciplines. The research organizations were selected from directories of research laboratories and from the card files of the Institute for Applied Technology, National Bureau of Standards, U. S. Department of Commerce, Springfield, Virginia. We also selected universities in geographical areas where there were industrial, independent, and government laboratories that we would visit. In all cases an effort was made to include both large and small laboratories of each kind in each geographical location. The approximate student enrollments of the universities were as follows:

21,000 - 34,000	(2)
8,000 - 12,000	(6)
4,000 - 7,000	(5)

Following the development of a list of research organizations, a letter was mailed to each Director of Research or Chairman requesting permission to visit. After permission was granted, a professional staff member went to inform the research leaders about what we were doing and why. He then discussed general problems and recommendations concerning informal scientific communications and requested the names of Project Directors whom we could ask to serve as participant observers.

The chairmen and directors were asked to name scientists in their organizations who were currently engaged in directing a research project in one of the various disciplines selected for study. The following 10 types of personnel (who do research in 160 specialties) were selected for intensive study:

	N
Physicist, Nuclear	8
Physicist, Electricity and Magnetism	17
Physicist, Other	46
Physicist - Total	71
Chemist, Inorganic; Analytical	36
Chemist, Organic; Biochemist	55
Chemist - Total	91
Mathematician	30
Physiologist	20
Microbiologist; Bacteriologist; Immunologist	21
Biologist - Total	41
Engineer, Electronic; Electrical	35
Engineer, Mechanical; Aerospace	14
Engineer - Total	49

The above scientists and engineers were employed in the following types of organizations:

	N
University	121
Industry	79
Government, Military	66
Government, Non-Military	26
Government - Total	92
Independent and Consortium	34

In all, 326 scientists and engineers who had responsibility for conducting research projects in their organizations were interviewed. The researchers who assisted us were drawn from 102 organizations.

Relation of Formal to Informal Communications

The sampl was requested to reply to the following question: "Give an example of how informal communications and published material complemented each other to supply you with information." From the examples given, we are able to observe the interface between formal and informal channels of communications, as well as the functions this relationship fulfills during the performance of R&D tasks. Total group percentages reflecting the communicative modes brought into play are shown below along with a breakdown as to whether the mode was used initially or secondarily.

	Percentages		
	First mode mentioned (N = 326)	Second mode mentioned (N = 326)	Total mentions (N = 326)
Published document	36	13	49
Inquiry to author(s)	11	28	39
General discussion	11	16	27
Inquiry to coworker(s)	8	5	13
Citation found in literature	10	2	12
Visit outside	6	6	12
Citation given by colleague	6	1	7
Preprints, unpublished reports, memos, etc.	4	3	7
Inquiry to vendor on equipment capabilities	< 1	1	1

When formal and informal modes of communication interact, communication is initiated most frequently by a document (49%), followed by interpersonal informal communication with the author or others. Engineers (56%) and scientists in industry (56%) appear to emphasize this type of behavior more than other researchers, while those in independent laboratories mention it least (30%).

General discussion seems to play a significant role in the interaction of formal and informal modes of communication (27%). Independent laboratories reported the highest rates of mention (36%) followed by mathematicians (34%). Government researchers reported at the lowest rate (22%).

Seeking information from coworkers enters into the formal/informal communications relationship (13%). The frequency with which this mode was put to use varied with the following subgroups: Engineers (7%), mathematicians (6%), researchers in independent laboratories (6%) were lowest, and in government laboratories (19%), highest.

Where formal and informal communications complemented one another, certain results were accomplished. These results are listed below with their respective percentages of mentions:

	Percent (N = 326)
Information comprehension	21
Acquisition of details of a study	21
Related information acquired	18
New leads and preliminary ideas	14
Solution of a problem	7
Interpretation of data	4
Awareness of a new problem	3
Awareness of negative results	2
Copy of an article	1

When responding that information comprehension resulted (21%), the percentages for deviant subgroups were: physicists (27%), mathematicians (27%), and biologists (12%). When responding that they acquired details on a study (21%), the percentages for selected subgroups were as follows: biologists (39%), mathematicians (13%) and physicists (7%).

Many scientists and engineers were convinced that informal communications were practically indispensable towards properly assimilating and digesting the formal communications. Often, published works appear fragmentary, incomplete and unreadable. A report may illustrate only a few salient points. One has to go to an individual to arouse interest as well as to supplement the report.

Published works are often excellent references, but to understand the latest thinking, informal contacts are needed to amplify and clarify information. This can contribute heavily to its usefulness. Published materials also will verify prior convictions and reinforce information produced by informal contacts. This type of informal feedback, which substantiates the facts as valid and meaningful, is instrumental in building confidence in a particular course of action.

Many scientists and engineers gave the impression of being overwhelmed with published literature. Library research requires a tremendous portion of their time, which often they can ill afford to give. Frequently, they will read only those items which have been recommended worthy by dependable colleagues. By requesting information from a reliable individual, that individual serves as a random access memory file. His judgment and experience assist in gathering information from formal and informal sources. Engaging in informal discussions with experts in a particular field was regarded as a highly important supplement to knowledge obtained from the literature.

A number of professionals felt that what they communicated informally almost invariably bordered on something they had read in the literature. This is particularly true when aspects of a new field have been published. Newness brings with it a nomenclature all of its own. Searching the literature often is viewed as preparation for approaching a field, enabling the professional to ask pertinent questions of specialists.

Researchers expressed the opinion that they are known by what they write, and this is vitally important. At meetings they will be approached informally by people who voluntarily exchange information. By this means scientists are alerted to new problems. Consequently, informal communications are seen as a constant check on published material. They often probe premature conclusions in a detailed manner and reveal flaws which could cause the report to contradict the facts and appear unsound. Resorting to both informal and formal sources results in familiarization with detailed properties of experiments. Occasionally, there is a problem in acquiring information to formulate an appraisal of equipment capabilities. Conversing with a manufacturer's representative is often the most profitable means by which insight and judgment as to expected and desired performance may be gained.

Formal communications were reported to be somewhat negligent in not expressing evidence of having confronted problems and how to deal with these problems under certain conditions. Reports often exclude mentioning negative aspects and over-promote promising features. Consequently, missing information must be obtained from attendance at meetings and consultation with other researchers. Scientists and engineers often contact sources informally. It is not unusual that these contacts supply the pertinent fragmentary bits of information concerning procedures and applications. Having access to these informal contacts is valuable if an adequate framework of thought is to be developed.

Informal communications often will lead to experimental or theoretical data which is unavailable in the current literature. There is often a troublesome publication lag which puts researchers at a considerable disadvantage. This time lag between published form and present developments lead to contacts with specialists who can update information regarding progress and current thought in the field under consideration. Scientists and engineers cannot be spoonfed information. Successful researchers comprehend the channels of information that are available and combine the various formal and informal modes to their own best advantage. They integrate suggestions and information gained informally with that which is gained from reading.

Occasionally, there are reasons for technical details not being published. There are aspects of research in any field which can not be categorized as being either factual or specific. The effects which these aspects may have on the work of those within the field cannot be accurately determined. Often they are qualitatively unknown. The literature interprets only that which is established. The responses regarding new ideas are not specific as to how to proceed or what to expect. When confronted with predicaments such as this, researchers seem to strongly rely upon informal information sources.

Evidence of the relationship between formal and informal communications was elicited by the following question: "In what way are informal communications essential to the transfer of scientific and technical information?" The percentages of mention of answers were:

	Percent (N=326)
To learn about the details of a study	19
To assist in finding published information	6
To keep aware of what is published	3

It is clearly apparent from the contents of interviewees' comments that formal and informal research communications are mutually dependent and complementary. Both are vitally necessary to continued research progress.

Difficult to Obtain Information

Our interviewees were requested: "Please give some examples of how informal methods brought you information that was difficult to obtain." The percentages of mentions pertaining to choice of method used in obtaining difficult information are as follows:

	Percent (N = 336)
Conversation	56
Meetings and conferences	19
Visiting	17
Telephone	17
Consultation	16
Letter	8
Newsletters	3
Trade journal ads	2
Vendors	<1
Visiting lecturer	<1

Interviewees heavily favored conversation as an informal means of obtaining difficult information (56%). There are exceptions, however, where subgroup percentages did not correspond with this total-group's percentage of mentions. The following subgroups gave mentions of "Conversation" as follows: Physicists (64%), chemists (50%), industry (64%), and government researchers (48%).

Attending meetings and conferences also was mentioned as means to get difficult-to-obtain information (19%). Two extreme percentage ratings were recorded for biologists (27%) and for independent laboratories (12%).

Relying upon visits was another approach for getting difficult information (17%). The highest rate of mention came from biologists (41%) and from independent laboratories (33%). Noteworthy also is the low percentage of mention on the part of researchers in industry (9%).

Telephoning was mentioned by 17 percent of all researchers interviewed, often by engineers (28%) and least often by biologists (3%).

The examples given depicted various types of information being received. The total group percentages of mentions for such types are as follows:

	Percent (N = 326)
Information solving a problem	30
Unpublished technical details and negative data	25
Maintaining awareness current in field	24
Physical data on material and apparatus	18
Information or background in another field	15
Different approach to a problem(s)	12
Interest in a new subject	6
Copy of article not yet published	4
Proprietary or classified material	3
Information in foreign journals	< 1

Information which solved a problem received the most frequent mention (30%) with industry recording the highest percentage (42%) and researchers in independent laboratories mentioning "problem solving" information least frequently (21%).

Informal methods appear to offer assistance with the task of gathering together unpublished technical details and negative data. Those subgroup percentages which deviate substantially from the total group percentage of 25 percent are as follows: Biologists (39%), independent laboratories (38%) and physicists (18%).

Likewise, informal methods contribute noticeably to current awareness in one's field (24%). Subgroup percentages at significant odds with the total group percentages are as follows: Biologists (39%), physicists (32%), engineers (15%), and mathematicians (13%).

Personal Contacts

Our interviewees were asked: "When you need scientific and technological information, how do you go about obtaining it informally?" Their most frequent answers are listed below with the percentages obtained for each answer:

	Percent (N=326)
Conversation within own organization	51
Contacting people in relevant field	50
Conferences and meetings outside own organization	16
Consultation with outside organization	6
Office reports and memos	5

Conversations within one's own organization was most popular among those employed in independent laboratories (65%), and least popular among those employed in universities (44%), and in government, non-military laboratories (46%). Biologists mentioned conversations in their own organizations most frequently (61%), whereas physicists had a much lower frequency of mention (44%).

Thus, it appears that personal contacts are a highly important means of obtaining needed scientific and technological information in all subgroups.

We also asked a special question about outside colleagues: "Do you communicate regularly with a group of colleagues outside of your organization about scientific or technical problems?" The following contact regularity percentages were obtained from examples that were requested:

	Percent (N=326)
Regularly (4 or more times per year)	56
Regularly (2-3 times per year)	8
Irregularly (rarely or occasionally when needed)	25
No	8

Several subgroups mentioned four or more regular outside contacts per year year considerably more frequently than other subgroups or the total group, as follows: Biologists (61%), engineers (64%), university faculty (63%), government laboratories (64%). Also noteworthy is the low rate for independent and consortium laboratories (38%).

Three major means of making outside contacts were mentioned by the total group as follows:

	Percent (N=326)
Telephone	50
Mail	20
Visit	10

Subgroups responded with rates of mention similar to those of the total group.

The types of persons contacted were mentioned by the total group with the following percentage rates:

	Percent (N=326)
Colleague outside organization	65
Colleague within organization	63
Consultant (outside)	9
Author of article	5
Vendors' representative	3
Invited speakers	3
Clients	2

Physicists mentioned colleagues within their own organization less frequently (51%) than other scientists who had rates similar to the total group. All subgroups responded very similarly about contacting colleagues outside of their organizations.

Values of Informal Communications

When asked about the values of regular contacts outside of their organizations, the total group responded with the following rates of mention:

	Percent (N=326)
To exchange ideas and information	42
To get help with techniques or problems	19
To save time in gathering information	6
To increase interest and gain stimulation	6
To give consultation help	3
To contact other fields and specialties	1

Biologists appear to favor making contacts regularly to exchange ideas and information (53%), whereas engineers were least likely to mention regular contacts for information (37%). Mathematicians were least likely to have regular contacts in order to get help with techniques or problems (10%), whereas engineers appear to value this form of help from regular contacts (24%).

With respect to informal scientific communications in general, we asked: "In what way are informal communications essential to the transfer of scientific and technical information?" The percentages of mentions of values were as follows:

	Percent (N=326)
To save time in solving a problem	39
To learn about current research	25
To obtain help in solving a problem	20
To become aware of unpublished work	19
To learn about details of a study	19
To learn about new ideas	13
To gather a variety of information on a topic	10
To assist in finding published information	6
To keep aware of what is published	3
To learn of failures and negative results	3
To train researchers	3
To save money in solving a problem	2

Biologists appear to be inclined to use informal communications with greater frequency than members of other disciplines to learn about current research (37%) and to become aware of unpublished work (27%). Physicists are inclined to view informal communications as a means of saving time in solving a problem (48%). Research engineers appear to be somewhat less likely than scientists to use informal communications to learn about the details of a study (11%).

Further indications about the values of informal communications were sought by asking: "Which phases of the research process require most informal scientific or technical communication?" The following percentages of mention were received:

	Percent (N=326)
Research planning	72
Development of methods, materials, and equipment	26
Throughout the entire research program	17
During interpretation of the results	16
When unexpected problems arise	12
At end of development phase	5

Development of methods, materials and equipment appears to be the most popular phase for informal communications among biologists (36%) and engineers (34%), and among government scientists generally (34%). Chemists and athematicians are most likely to mention interpretation of results more frequently than other researchers (23% each).

When we asked why the research phase mentioned requires the most informal communications, the following percentages were mentioned for values:

	Percent (N=326)
To clear up thoughts and ideas	34
To learn from other experts	18
To get help on specific problems	16
To save time	7
To find out about current work	7
To learn about unpublished procedural details	5
To explain applications	5
To obtain proprietary information	< 1
To learn about failures	< 1

Biologists seem to prefer to use informal communications more than other researchers to clear up thoughts and ideas during research phases (44%), whereas engineers appear to be least likely to mention this value (27%).

Other information about the values of informal communications was acquired from the following question: "Which types of scientific or technical information are best communicated by informal means?" The rates of mention were as follows:

	Percent (N=326)
Ideas and new interpretations	30
Details of research project design	29
Information about current research	19
Knowledge of unpublished results	15
Clarification of someone else's results	13
Information leading to understanding of problems	12
Theory building information	11
Details about equipment	11
Critical evaluation of one's research	7
Failures and negative data	4
All types	4
To learn if a problem has already been solved	3
Information about other disciplines	3
Explanation of reasons for doing a project	1
Analytical and mathematical formulations	<1
Capabilities of suppliers	<1

Biologists again mention details of a research project design most frequently (44%), and mathematicians were least likely to mention ideas and new interpretations as a value (17%).

Assuming that current awareness is an important value to scientists and engineers, we asked them: "How do you keep your <u>general</u> background of of knowledge up-to-date by means of <u>informal</u> communications?" The rates of mention were as follows:

	Percent (N=326)
Meetings (society, committee, etc.)	43
Conversations outside own organization	39
Conversations with coworkers	36
Seminars, lectures and colloquia	25
Preprints and unpublished reports	19
Correspondence	9
Visits	8
Conferences in own organization	7

Chemists mentioned meetings of societies and committees more frequently than other disciplines (55%), and biologists mentioned such meetings least frequently (34%). Physicists mentioned preprints more often than researchers in other disciplines (27%).

Motivation and Innovation

Among the previously covered functions of informal scientific communication, we found a substantial list of its contribution to both motivation and innovation. With respect to motivation we requested: "Please give an example of how informal communications contribute to research motivation." The examples classified gave the following percentages of mention:

	Percent (N=326)
Conversation sharpens interest in a subject	23
Conversation generates new ideas leading to new research	23
Conversation reveals important problems to work on	14
Sense of competition gives impetus to complete a project	8
Presentation or lecture stimulates new ideas	6
Discussion of problems leads to research on systems	5
Visit led to new research program to improve a product	3
"Brainstorming" led to research to solve a problem	2
Visit to discuss failure continued effort toward a better system	2
Information on surplus equipment led to new research	1

Although the innovative effects of informal communications were elicited by the above question on motivational effects, we also had requested information on innovation as follows: "Please give an example of how an informal communication contributed to an innovation." The results were the following percentages:

	Percent (N=326)
Discussion of ideas led to a new product or method	18
Visit led to new ideas and improvements	12
Conversation led to a problem solution by a new method	8
Discussions revealed a new design for a different use	7
Consultation on methodology led to a new solution	6
Discussion of problems suggested a new method of solution	6
Interdisciplinary discussion led to successful operation	5
Author provided information used for an innovation	2
Questioning assumptions led to a solution	2
Paper at meeting generated idea for a new application	2
"Brainstorming" a problem led to a solution	2
Preprint provided background for an innovation	<1

Information Exchanges

A number of interviewees mentioned the Information Exchange Groups previously sponsored by the National Institutes of Health. The Groups were generally considered to be a good idea in principle. The Information Exchange was seen as a means of exchanging preprints of research in the form of informal accounts of work underway. They valued the partial results from current long-term studies that were reported as well as the information about who was doing what and where. In general, such a service was seen as being best handled by a central agency or clearinghouse for informally reproduced material. Some indication of attitudes about information exchanges can be obtained from the responses to the following questions:

"How can we improve informal technical communications over long distances?"

	Percent (N=326)
Distribute information on current research	5
Establish a central preprint information service	< 1

"What else can be done to improve informal scientific and technical communication in general?"

	Percent (N=326)
A central index of publications and topics	8
Encourage distribution of preprints	7
Produce newsletters on who does what and results	1
Provide information on availability of informal scientific communications	< 1
Develop a national preprint distribution service	< 1

Another service which was deemed to be valuable as a function of the Information Exchange Groups was publication of lists of articles submitted for publication, summarized by specific areas in each field. It also was said that being on a sufficient number of preprint lists enabled scientists to know what is happening many months in advance and to stay up-to-date.

Informal newsletters or newspapers were advocated by a number of interviewees to perform an abstracting and reviewing function, so as to provide researchers with more effective current-awareness information. This type of communication was seen as being useful by providing notification about what is going on or helpful hints in conducting research. It was said that newsletters serve to keep scientists in a specialty up-to-date in current research with respect to who is doing what and where. The desired type of article would say that so-and-so is working on a problem, and would give the nature of his results and his location. Research projects and programs can go on for years without formal publication of information until they are finished. During that time there may be researchers who are doing related work in other parts of the country who can be helped by knowing that others have been working in the same area of research.

a-Organization Communications

In order to uncover information concerning problems of informal communications within organizations, we asked: "What would help to improve scientific and technical communications within your organization?" The following percentages responded as indicated:

	Percent (N=326)
More seminars and symposia	11
Circulate information on work of others in organization	10
Better agenda	10
More interdisciplinary communication	9
More "brainstorming" discussion sessions	8
More funds for inviting researchers to visit	6
Better choice of topics at conferences	6
More time for attendance at seminars	6
Better speakers at conferences	5
Better physical facilities for conferences and meetings	5
Stronger chairmen to hold to agendas	5
Distribution of preprints of topics to be discussed	5
Periodic oral reviews of research	4
More funds for visiting other researchers	3
More comprehensible paper presentation	2
More time to prepare for presentation of work	2
Protection of scientists' original ideas	1
Draw out those who have not fully reported their work	1
Use large conferences for information, not problem solving	1
More staff or faculty meetings	<1
More time to talk about areas of interest	<1
Organize trips to factories or institutions	<1
Provide uncommitted funds to use on unexpected problems	<1
Hold a yearly sponsors' conference at our laboratory	<1
Provide persons to review and recommend literature	<1
Better publicity to announce seminar	<1
Better projection equipment	<1

In general, the percentages of mention reported above are too small to make comparisons among sub-groups worthwhile. It is noteworthy, however, that there was a general emphasis on improving seminars, conferences and meetings of all kinds within organizations. Mentions of needs for more funds to improve intra-organizational communications also resulted from the above general question. We asked the following question to provide greater detail about time and funds needs: "Have you had problems in obtaining time or funds to complete informal scientific or technical inquiries?" The interviewees then were asked to give examples, which have been tabulated as follows:

	Percent (N=326)
Finding time to visit to obtain information	19
Strong justification needed for travel	12
Travel to meetings restricted	9
Telephone calls restricted	4
Finding time to locate those who have information	4
Travel limited as to distance	3
Travel to other laboratories restricted	3
International travel restricted	2
No travel allowed	2
Finding time to prepare papers for meetings	2
Funds for consulting fees restricted	1

With respect to funds in particular, we asked: "How are informal technical communications supported by your organization?"

	Percent (N=326)
Travel fund available	22
Unrestricted use of telephone	17
Support of seminars and lecture series	16
Allowance of time off to attend society meetings	14
Informal get-togethers	9
Circulation of progress and technical reports	4
Not supported	4
Staff meetings	3

	Percent (N=326)
Availability of consultants and advisors	2
Support for writing preprints, etc.	2
Suitable conference facilities	1
Unrestricted mailing privileges	1
Expense account (e. g. , dinners)	<1
Funds provided to attend courses	<1
Preprint library	<1

Utilization of Paid Consultants

Our interviewees were asked, "What outside sources of paid consultants have you utilized?" Their responses are listed below with the percentages obtained for each answer:

	Percent (N=326)
None	57
Specialist	17
University professor	13
Contractor	8
Hired people on fellowship or temporary basis	2
National Academy of Science advisors	1

Universities gave the greatest evidence that consultants were not employed by their organizations (83%), whereas the percentage within industry was 33%. The tendency not to employ consultants was similar for military (45%), government, non-military laboratories (46%), and independent and consortium laboratories (47%). The percentages reported back by the various disciplines were: mathematicians (63%), chemists (55%), physicists (57%), biologists (70%) and engineers (50%).

The employment of consulting specialists within the observed organizations produced the following percentages: Industry (30%), independent and consortium laboratories (18%), government (16%) and universities (6%).

Those organizations utilizing university professors were: Industry (27%), military (17%), government, non-military laboratories (8%), independent and consortium laboratories (15%) and universities (2%). Disciplines which used university professors were: Chemists (12%), physicists (12%), engineers (16%) and mathematicians (10%).

Concerning the use of commercial contractors, combined government organizations registered the highest percentage (17%), followed by much lower frequencies from the universities (4%), industry (4%), and independent and consortium laboratories (3%). In regards to the discipline, only mathematicians (10%) and the engineering group (13%) reported using contractors.

Inter-disciplinary Information

We asked, "How do informal communications enter into inter-disciplinary research?" The total group responded with the following percentages:

	Percent (N=326)
To broaden knowledge available to solve problems	24
To obtain specialized information	20
To solve problems no solvable by a single individual	15
To keep in contact with other specialties	8
To exchange ideas	6
To improve the quality of research	5
To speed up the pace of research	4
To obtain specialized services (e. g., measurements, equipment)	3
To obtain awareness of unperceived problems	2

Broadening one's knowledge of other disciplines which would assist in solving problems was mentioned most frequently (24%). Among organizations considering this question, independent and consortium laboratories appear to mention this reason most frequently (35%). With respect to disciplines, mathematicians mentioned this cause most frequently (30%) while chemists produced the lowest percentage response (19%) of the disciplines.

Emphasis on interdisciplinary information concerns were also elicited by the following questions:

"Which type of scientific and technical information are best communicated by informal means?"

	Percent (N=326)
Information from other disciplines	3

"What would help to improve scientific and technical communications within your organization?"

	Percent (N=326)
More interdisciplinary communication	9

"Please give an example of how an informal communication contributed to an innovation."

	Percent (N=326)
Interdisciplinary discussion about a problem uncovered its cause	1
Interdisciplinary discussion led to a successful operation	5

Research scientists and engineers rely heavily on consultations with colleagues in their own and other disciplines to acquire information they need in the conduct of their research. Mathematicians are among those most frequently consulted by members of other disciplines. More often contacts are made with specialists in the same field who have been determined to be persons who have worked in the subject matter area of interest previously. In the field of engineering, however, there is a constant consulting relationship between those responsible for engineering applications of science to the scientists who are specialists and who have or can generate knowledge related to engineering problems. Thus, for example, engineers frequently will consult chemists to find a metal with special properties to do a particular job. Similarly, electrical engineers seek consultation in such specialized scientific areas as plasma physics. Research scientists also are assisted in turn by engineers who are consulted when new types of equipment must be designed and developed to meet scientific research needs. And, finally, scientists consult scientists; for example, as one researcher stated, "If you are a chemist and you encounter a problem in physics, first thing you do is to go to your friendly physicist and ask him about it."

Other areas of interdisciplinary research are similarly approached on a consulting basis and the response to our question suggests that interdisciplinary problems are primarily handled by consultation among specialists who continue to work on their own problems in their own fields. Very little evidence was encountered to indicate that interdisciplinary teams are popular in the sciences. The results of our content analyses indicate, however, that such interdisciplinary teams are to be found with considerable frequency in the engineering disciplines, or where technological developments are the primary point of emphasis for a research project.

Consultations also occur with frequency and productivity between the researcher and the representatives of the equipment manufacturers of materials suppliers. By this means the professional researcher learns of new tools available, obtains assistance on equipment requirements, and information about equipment capabilities. Oftentimes the researcher will go directly to the laboratories of suppliers for assistance in solving problems of research. As one scientist put it, "If a contractor's representative visits you he gives you a broad treatment of all the area of interest to his company. This is useful information exchange." For example, if the development of a special electric connector presents problems in mechanics, chemistry, and engineering, one can involve a number of specialists who represent vendors.

The development of engineering systems are said to be due mainly to the merging of different disciplines. Each type of equipment has its own peculiarities that are best understood by people specializing in that type of equipment, yet they must all work together to account for the peculiarities of each one.

A number of specialists indicated that informal communication, primarily by direct oral contact, is the method by which they are best able to get a cross-over of ideas among different disciplines. Thus cross-fertilization which leads to creative scientific and technological results can be traced to the interdisciplinary mode of exchanges of specialists who remain alert to the events in fields other than their own. The points of contact in the course of generating new research is indicated to be that help is needed by experts who helped to set up the equipment or to make measurements or to evaluate results. These contributions serve to speed up the pace of research and to improve precision and technical quality of the results it produces.

The specialist has a fair prospect of finding what he wants by reading his own technical literature. Where other disciplines are concerned, they may have different languages and different concepts. Thus, although teamwork occurs among scientists in the same specialty, the further one goes from a specialty of a particular discipline toward applications of scientific knowledge in general, the greater is the likelihood that interdisciplinary teams will be found working together.

By and large, the transcripts of our tape recordings indicate that most consulting is done on a mutual and friendship basis rather than on a professionally paid consultant level. Even where a specialist is able to locate particular information he requires in the literature, it is often necessary to consult with a colleague in order to be able to understand the information. It appears also that the size of the organization is a factor in determining the consulting patterns of scientists and engineers.

Large organizations staffed by many men in many disciplines have a variety of specialists who are easily accessible to those who need assistance and are paid by the same employer. But, nevertheless, friendship ties crossing organization boundaries permit the inquiring scientist or engineer to go beyond his own organization virtually at will without expenditure of organizational funds.

Study groups and symposia can provide optimum exposure towards gaining significant information in other fields. Such informal sources can be most illuminating when they pull in knowledgeable people from various fields. Interdisciplinary information transfer is most effective when they present their ideas at a level that is suitable for listeners from other fields.

Directory of Specialists

Researchers expressed a need to know who was doing what, and where, and with whom one should communicate to get unpublished information. A need was stated for some place where topics and people could be related in a high degree of definition. A scientist needs to know whom to consult for information and where he is located. In particular, he wants to know others who are working on problems similar to his, who has conducted research on it, and who is up-to-date in the specialty. This is particularly important when a problem is encountered during research or planning.

The problems of acquiring certain information informally were brought out by the following question: "Have you had any problems in obtaining time or funds to complete informal scientific or technical inquiries?"

	Percent (N=326)
Finding time to locate those who have information	4
Obtaining consultant fees	1

Evidence of the need for guidance to specialists who can be called upon for information and advice was found from the following question: "What else can be done to improve informal scientific and technical communication in general?"

	Percent (N=326)
Develop a cross-file of specialists and their current topics	10
Improve communication between applied research and basic research	3
Develop a method for communicating negative results and failures	< 1
Provide more information on availability of informal scientific communications	< 1

It was said that often scientists spend as much time getting the names of persons to consult as they spend delving into the problem. In this connection, it was noted that there has been a tendency to rely on just any technical expert, often one who is out of his field. A small amount of communication with those intensively interested in an area, it was stated, was worth more than much discussion with people who have only peripheral interests.

Visits

Considerable expression of dissatisfaction with current opportunities to visit was expressed by our interviewees. The responses to the following questions illustrate their needs and suggested solutions.

"How can we improve informal technical communications over long distances?"

	Percent (N=326)
Develop visiting and exchange programs	23
Provide more funding for travel	21
Send representative of broad background to visit other laboratories	<1

"What else can be done to improve scientific and technical communications in general?"

	Percent (N=326)
Encourage visiting programs	12
Better funding for travel	9

With respect to improving communications over long distances, biologists mention a need for more travel funds at a considerably greater rate than do other researchers (30%), and they also mention needs for visiting and exchange programs more frequently (31%). Although government researchers do not mention need for funds with above average frequency (15%), a high percentage of them mentioned needs for visiting and exchange programs (30%).

University researchers mentioned need for travel funds (30%) at a considerably greater rate than need for visiting and exchange programs (20%). Independent and consortium researchers showed a pattern similar to university researchers (15% for travel funds, 33% for visiting and exchange programs). Industry scientists showed low percents mentioning both needs (17% and 16%, respectively).

While utilizing equipment for the first time, it is most helpful to visit men in outside laboratories and organizations who are involved with corresponding equipment. This permits professionals to experience other set-ups. This is often a necessity since it is not uncommon for organizations to neglect the writing of descriptive matters and technical reports in the interest of putting the project into operation. When reports are read, it can be difficult to conceive the nature of the equipment or to appreciate the physical necessities which dictated the equipment's arrangement. From visits, professionals obtain impressions of what has been done so that their efforts will not be wasted either through error or duplication. The import of the information consists of verifying the capabilities and susceptibilities of the equipment and the examination and deduction of data and techniques of operation.

Visits to other laboratories were said to enable scientists to accumulate information about types of equipment, equipment set-ups, new methods, and techniques that would not otherwise become known to them until much later contacts were made. Visits enable scientists to learn the nature of other laboratories, and to learn what they can do and what they cannot do, and arrangements can be made to utilize equipment that might not otherwise be available. Visits enable scientists to get leads to explore new areas beyond their present work by obtaining other views from the researchers visited. A number of researchers noted a desire to have more outside scientists invited as speakers to attend their seminars and conferences in order to provide outside information that is up-to-date but not otherwise available.

More long-term visits also were advocated, ranging from several months to a year. During long-term visits, researchers would participate in work in the laboratories visited, and a more thorough and complete exchange of information between the visitor and the visited could be effected. The Visiting Scholar Program also was advocated, especially in connection with foreign scientists. Foreign scientists, it was stated, are those that are the most difficult to communicate with, although communications do occur. In this connection, expansion of sabbatical leave and fellowship programs was advocated as well as increasing support for such travel from other means.

A number of scientists advocated increasing the utilization of visiting lecturers as a means of transmitting information about research being done at other laboratories. It was noted that there is a need to improve the availability of funds to small research organizations so that speakers could be brought in. The speakers, it was said, should provide lecture information and spend a day or two in talking with faculty and students, thereby providing them with access to the newest techniques and ideas.

A direct method of obtaining information to be returned to a parent organization was suggested by a few interviewees, based on the use of traveling communicators. It was noted that one man of broad background could travel extensively to derive information for various specialists working in his organization. Visits of this kind were advocated both to U. S. laboratories and to foreign laboratories.

Improved Use of Communications Technology

Researchers note with chagrin that the technological products of their efforts are not yet being effectively applied to improve scientific progress. The following questions and answers illustrate their trains of thought on technology:

"How can we improve informal technical communications over long distances?"

	Percent (N=326)
Make telephone calls cheaper	18
Project image while talking on telephone	17
Provide unlimited telephone service	6
Improve mail services	5
Closed-circuit TV broadcasts of meetings	2
Facilitate telephone conferences	1
Follow-up telephone call with teletype or night letter	1
Computerize information banks searched over telephone	1
Send tape recorded messages	1
Record and store distinguished lectures for distribution	1
Provide satellite channel for scientific and educational communication	1

"What can be done to improve informal scientific and technical communications in general?"

	Percent (N=326)
Improve facilities for communication (mail, telephone, closed circuit TV, etc.)	6

Thus, many scientists and engineers perceive a great need for applications of available communications technology to the enhancement of science and technology. In particular, there was expressed a strong need for a means to present information visually over long distances, such as parts, graphs, sketches, diagrams, pictures, formulas, equations, blueprints, and other items that provide the day-to-day basis for communicating about scientific and technological work. Systems such as the electronic blackboard and the video telephone have been developed to meet the need. By these means, it was said, a considerable expenditure of funds for travel to discuss problems could be avoided, as well as long time delays that result from using the mail to send schedules, diagrams, photomaps, etc. As one researcher put it, "An engineer frequently needs to see what the person is doing with whom he is holding a discussion on the telephone, such as when there is a question about an equation, or an analysis that needs to be written to be understood." The electronic blackboard, perhaps, would be sufficient in itself to enable researchers to indicate in writing that which is best understood when visually symbolized. But documents such as blueprints, schematic wiring, photographs of equipment set-ups, and other visual information require a large-screen adaptation of the video telephone.

A second suggestion for a use of video technology concerns closed-circuit television broadcasts as a substitute for traveling to other laboratories, conferences and meetings. By video means, seminars or meetings at one place would be immediately available to a large number of viewers at other locations. It was suggested that a special UHF channel could be made available for scientific communication purposes, and that a communication satellite channel could be provided for broadcasting to researchers.

A number of scientists indicated a desire to preserve by recording the lectures of distinguished visitors. It was felt that the availability of a library of audio and video tapes could be used extensively for the purposes of training graduate students and for up-dating scientists and engineers in special subjects. Domestic and international meetings and interviews could be distributed at a much lower expense than is required to travel to them. It has been proposed to have each speaker on a program pre-tape his talk for a library from which copies may be drawn by those who wanted to hear what was said. A library of tapes could provide an acceptable means of improving interdisciplinary communications, most of which are now done through informal contacts, often involving travel.

In addition to using tapes for the general dissemination of information, mention was made by several researchers that personal tape recordings are now highly practical. They could be used by individual scientists to a much greater degree than is currently common in order to communicate inexpensively, but extensively with those who are at considerable distances.

It was noted that at certain times utilization of teletype messages can be an efficient way of accomplishing in a high-speed manner what is normally done on a delayed basis by mail. This means of communication is, perhaps, the most economical and efficient when there are very long distances involved.

Restrictions on Information Transfer

Security classification and proprietary interest problems came in for a share of the attention of our interviewees. The answers following the questions below provide an indication of the kinds of considerations that they were concerned with.

"How can we improve informal technical communications over long distances?"

	Percent (N=326)
Enlarge network of scramble phones for classified information	3

"Please give some examples of how informal methods brought you information that was difficult to obtain."

	Percent (N=326)
Proprietary or classified material	3

"What else can be done to improve informal scientific and technical communications in general?"

	Percent (N=326)
Remove proprietary restrictions	5
Do not security classify openly available information	1

A number of comments were elicited about the influence of security classification requirements on the conduct of science and on the maintenance of scientists' current awareness of events that influence their work. It was noted that security requirements are limiting in many respects. They frequently require individuals to travel to exchange information that might otherwise be communicated by telephone conversation. It also restricts technical communication with vendors since often the proposed use of needed material, such as chemical compounds, cannot be revealed, and the vendor is thereby rendered unable to suggest substitutes which might possibly be more effective. As one scientist put it, "There is so much emphasis on protecting our research that we are preventing the appropriate interchange of information." Security often has the opposite effect to what is desired - stifling work that is going on rather than encouraging it. Among the things most commented on were arbitrary security classification, which often results in classifying work that is already well known. A quicker declassification of information was said to be needed, and much that is classified should not have been classified. There appears to be a tendency to over-classify information just to be on the safe side, without regard for the consequences of limiting an open exchange of scientific information.

A suggestion was made to assist in remedying the problem of communicating outside of one's organization to the effect that a larger network of scramble phones should be employed. Another aspect of the problem of security classification involves restrictions on communication based on the "need to know."

A second source of restrictions on the transfer of scientific information concerns the proprietary requirements of industrial laboratories. The proprietary restrictions are designed to prevent competition from acquiring information about new discoveries, either before patents are awarded or where other trade secrets might be involved. It was said that when researchers talk to colleagues representing commercial organizations, it is difficult to exchange information of mutual interest, and at scientific meetings this is one of the biggest obstacles to exchanges of ideas. One problem is to alleviate the fear of being outbid on a contract. It was said that much "proprietary" information is not as secret as is commonly thought, and that much duplication of work could be avoided by increasing disclosure.

Although scientists in university positions frequently comment that when industrial scientists visited them they do not say anything of importance, it was also noted that in many instances university scientists themselves refrain from communicating information about their ongoing research projects. Researchers are close-mouthed about their work because they do not want to disclose prematurely an area of research that they had found to be productive. It was said that there was a literal race to do some research projects. The whole idea of the "publish or perish" philosophy prevents making policies that would permit researchers to work openly.

Meetings of Professional Societies

Among the questions of greatest importance in providing suggestions for informal communication was the following: "What can be done to improve meetings of scientific and technical societies?" In all, 27 different answers were obtained with varying frequencies of mention as indicated in the section below. Considerable criticism was leveled at the meetings of national societies of all disciplines studied. In particular, evidence was produced that both the way in which information is communicated and the physical and organizational circumstances which surround national meetings are not satisfactory to a large fraction of those who attend.

Size of National Meetings

Most scientists and engineers say that national meetings are becoming too large. In general, the impression one gains from their comments is that the size of the meeting is inversely proportional to its value. This attitude, however, appears to be related to a general favorable attitude about conferences limited to 100 or fewer persons, as contrasted to national meetings which attract many thousands. Among the complaints voiced most often were statements that paper reading sessions of interest to the respondent frequently are found to overlap in time and are too widely separated in distance. National meetings are becoming so big that it is difficult for a scientist or engineer to hear all the papers that he wants to hear. It was suggested that more local meetings should be encouraged by national associations as well as more small meetings of specialists. The following percentages of mentions concerning size were reported:

	Percent (N=326)
Smaller groups desired	30
Limited, specialized topics	22
More general broad topics	4
More interaction between researchers and specialists	3
Better control of meetings by chairmen	1
Enlarge to include more foreign scientists	<1

There appears to be a definite advantage in having societies arrange for small groups of specialists. This was favored most by universities (40%), followed by chemists (39%), biologists (37%) and least by mathematicians (20%).

Most subgroups were united in remarking that there is a need to present more limited, specialized topics. Although the subgroups' percentages of mentions were fairly consistent with one another, two subgroups took exception to this. They were: engineers (12%) and independent laboratories (12%). Even these lower rates of mentions substantially overshadowed the total group percentage (4%) which recommended more general, broad topics.

One additional question which bore relevant data was: "What <u>else</u> can be done to improve informal scientific and technical communication in general?" The total group percents of mentions for these recommendations were as follows:

	Percent (N=326)
Smaller, more specialized national meetings	6
Send all members of team to meetings concerning their work	<1

Another problem involves the use of national meetings as a place to meet other researchers who are doing work of interest to the attendee. Although meetings are said to be growing so large that it is often difficult to talk to those you would like to talk to because they are difficult to locate, it was also noted that large meetings have a potential for many more interactions between researchers than small conferences and local meetings.

Another advantage of large national meetings is the fact that they provide a basis for interdisciplinary and interspecialty exchanges of information, but this of course would not occur when groups are restricted to persons having a common research interest. In some cases the size of the whole meeting was not thought to be a determining consideration but, rather, it was the size and conduct of individual sessions that was emphasized.

Number of Meetings

A number of scientists noted that there are too many scientific and technical meetings, and that the number of meetings should be reduced considerably. In addition, meetings of different societies overlap in time. It was stated that frequently the same papers are presented at meetings of more than one society.

When our sample was asked: "How can we improve informal technical communications over long distances?", only one percent of the total sample advised that there should be support for more international conferences.

The interview put forth the question: "What can be done to improve meetings of scientific and technical societies?" Less than one percent of the sample recommended eliminating the duplication of papers at different meetings.

Length of Meetings

Durations of national meetings were subject to criticism, in that most were felt to be too long (four or five days). In addition, it was said that there are too many papers presented so that one gets fatigued. It appears to be generally believed that most national meetings have too many papers for the number of days that are allowed. Two remedies were suggested: (1) have some evening sessions, and (2) have shorter paper presentations, but the strength of feeling about this problem is not very high.

When our sample was asked the question: "What can be done to improve meetings of scientific and technical societies?", several recommendations of the 27 items mentioned referred to the length of meetings. They are as follows:

	Percent (N=326)
More evening sessions	1
Use fewer days	<1

Meeting Structure

The usual structure of national meetings of scientific societies apparently still involves the presentation of short papers, one after the other, with relatively little time in between for discussion. A general attitude of the interviewees is that national meetings should be structured in such a way as to permit and contribute to more informal discussion than apparently occurs now. Other points mentioned about meeting structure were as follows:

	Percent (N=326)
Allow more time for discussion after presentation	10
More roundtable-type discussion groups	7
Distribution of preprints before a meeting	5
Provide advanced information about agenda	3
Prominent speakers	2
Provide means to contact people after paper is read	1
Have workshop conferences of contributing specialists	1
Schedule related areas at different times	<1

Interviewees, within all the disciplines under consideration, urged that societies should provide for more discussion time following a presentation. Biologists mentioned this most often (17%).

A desire was noted for the provision of rooms where informal discussions could be held and a common suggestion was to provide preprints of the papers and to use time at meetings to discuss the contents of the preprints. Interviewees, in general, believe this would contribute to their understanding of the subject matter and reduce the number of poor presentations that must be endured in order to obtain the desired technical information. Under these conditions, it was said, a brief summary would be sufficient, leaving the remaining time for personal interactions and discussions.

Other suggestions included the increase in number of social hours for specialties, long coffee breaks so that sufficient time could be arranged to meet others without the pressure of missing an important session, and workshops for general meetings in the evenings. It was also stated that more symposia would be valuable, more papers invited from prominent specialists were desired, and if papers are to be read, then there should be "discussers" who are prepared in advance to develop questions and make critical comments.

Two items of interest were offered when the sample was asked: "How can we improve informal technical communications over long distances?" The total percentage of mention follows:

	Percent (N=326)
Set up more small working conferences in specialty	7
Preprint distribution before a meeting	<1

It is noteworthy that more biologists requested small, specialized conferences than researchers in general (12%).

Meeting Facilities

In connection with the conduct of meetings, the currently utilized physical facilities were criticized as being very crowded; so that informal talks going on in the hallways make it difficult to hear the formal talks going on in the paper reading sessions. In other cases lighting conditions are said to be inadequate or the lack of adequate aids to the presentation of information, such as blackboards and suitable visual aids. Often, the chairs were criticized as being uncomfortable.

When our interviewees asked the question: "What can be done to improve meetings of scientific and technical societies?", numerous suggestions about meetings facilities were offered. These improvements are presented below with their respective percentages of mentions:

	Percent (N=326)
Better facilities for informal meetings	7
Decrease distance between places where papers are read	2
Provide the means for visual communication	1

Regarding the expressed need for better facilities to conduct informal meetings, the rates of mentions for this suggestion were highest for mathematicians (15%) and for researchers employed in independent laboratories (12%). Biologists felt the least need (< 1%) for improved facilities.

The question was asked: "How are informal technical communications supported by your organization?" Only one percent of the total group stated that suitable conference facilities were provided.

Another question asked was: "What would help to improve scientific and technical communications within your organization?" The result was as follows:

	Percent (N=326)
Better physical facilities for conferences and meetings	5
Better projection equipment	< 1

Funds for Meeting Attendance

The question was asked: "Have you had problems in obtaining time or funds to complete informal scientific or technical inquiries?" Relating to problems over funds, nine percent of the total group mentioned "travel to meetings." Subgroup deviations were: government (14%), biologists (14%) and mathematicians (< 1%). When asked: "How are informal technical communications supported by your organization?", only 22 percent of the total group stated that their organizations supported them with travel funds. Subgroup deviations were: chemists (28%) and physicists (16%).

Local Research Society Meetings

In an attempt to determine participation in local professional society activities, we asked the following question: "Do you attend monthly meetings of a local professional society?" Those who answered "Yes" (47% of our sample) affirmed that they were currently attending such meetings. Then they were asked: "Why are they valuable?" The percentages of mentions were as follows:

	Percent (N=326)
To obtain information in specific field	33
For information exchanges with members	21
To acquire general background information	8
To learn about new ideas	7
To obtain details about new research	6

The percentages for the subgroups obtaining information in a specific field approximated the percentage registered for the total group (33%). The subgroups most frequently mentioning this item were: chemists (40%) and biologists (39%). Mathematicians presented the lowest frequency of mention (13%).

The subgroup percentages reporting on the significance of member interchange generally appear at variance with the total group percentage (21%) as follows: chemists (33%), biologists (29%), engineers (13%), and mathematicians (7%).

With respect to mentioning the hearing of new ideas, biologists (15%) and engineers (12%) mentioned this reason more frequently than the total group (7%).

Thirteen percent of our sample claimed that while they did not attend monthly meetings of a local professional society, they would involve themselves in such activities if meetings of this nature were made available to them. Subgroup percentages were not always in general agreement with this impression which the total group percentages offers. Instances of this are: mathematicians (23%), physicists (20%), engineers (10%) and chemists (9%).

Interviewees who responded "No" when asked if they would attend if such meetings were made available (40% of the sample) then were asked: "Why not?" The following percentages of mentions were recorded for each reason given:

	Percent (N=326)
Not in field of interest or work-connected	41
Not worth the time or money	26
Too general	11
Over-organized	2

Subgroup percentages deviated from the total group percentage where meetings were felt to be non-related to one's work or field of interest: physicists (49%), chemists (34%), biologists (34%) and independent laboratories (26%).

The subgroup percentages distinguished themselves from the total group percentage when judging such meetings as not worth the time or money. This is reflected by the following: independent laboratories (42%), universities (32%), engineers (21%) and government (16%).

A variety of suggested improvements materialized from having our sample respond to the question: "What else can be done to improve informal scientific and technical communication in general?" The percentages of mentions for suggestions made were as follows:

	Percent (N=326)
Better choice of topics at conferences	6
More time for attendance at sem[illegible]s	6
Stronger chairman to hold to agenda	5
Periodic oral reviews of research	4
Use large conferences for information, not problem-solving	1
Yearly sponsors' conference at our laboratory	<1
More staff or faculty meetings	<1
Better publicity to announce seminar	<1
Have meeting attendees brief those not attending	<1

Subgroup deviations for above mentioned item: Stronger chairman to hold to agenda: engineers (12%) and government (11%).

Small Group Conferences and Courses

The following rates of mention were reported to suggest small group conferences and courses in response to the question: "What else can be done to improve scientific and technical communication in general?"

	Percent (N=326)
Specialized university symposia open to all	1
Short courses or seminars on new developments	1
More small, specialized invitational conferences	1
Hold more problem-solving seminars	<1

Desire often was expressed by interviewees for greater numbers of small group conferences. There appears to be a confusion in the minds of the respondents between the size of the national society meetings and the size of individual session meetings of which it is composed. Furthermore, many scientists are familiar with conferences of invited specialists, with attendance limited to approximately 100 participants. In general, however, the comments concerning all of the above types of gatherings indicate that scientists are primarily concerned with increasing the opportunities for interaction for group discussions and for personal conferences with others who are doing work that interests them. Two types of small group meetings, limited approximately to 10 to 20 participants, are considered to be valuable: (a) informal groups of discussants who are highly specialized in the same field and (b) conferences of small groups with members from other disciplines who can supply interdisciplinary information.

Informal meetings with small groups also serve the purpose of communicating information about formally published documents, since most researchers do not have time to review all reports in their fields. Informal meetings with small groups with a relatively fixed agenda provide amounts of basic information concerning what is in the literature. In this connection many researchers advocate organizing more opportunities to hear good summaries of the latest state of the art. Some indicate that this could be done through symposia; others, through short courses at universities; and still others note that contractors' symposia held by government agencies, such as that held by NASA, are useful and informative. The pressure of work at the home institutions makes it difficult to stay aware of what is going on in one's field. At the retreat-type conference, however, being taken out of that environment and put in an isolated place provides time and a suitable atmosphere for thoughtful exchanges.

The most frequently mentioned conference of the informal retreat-type was the Gordon Research Conference, which is a series of week-long summer gatherings of about 125 invited researchers. The Gordon Research Conferences are set up in such a way that approximately two invited specialists present informal descriptions of their work and interests for approximately one-half hour in the morning, followed by a half-hour or more of discussion, questions and answer style, between the speaker and the audience. Afternoons are left free for informal contacts with the speakers and with others who attend. A similar procedure is repeated each evening.

There is an apparent rebellion against the relatively rigid structure of meetings which do not allow sufficient time for personal discussions. A number of suggestions included structuring meetings along the lines of the Gordon Research Conferences. A desire also was expressed for sessions that are relatively specific in their focus on subject matter. Special interest groups involved in round-table discussions were recommended. This is, in effect, expression of a desire to have organizations' national meetings structured along the lines of conferences of specialists. In general, there was a strong desire for fewer papers that are longer, better presented, and of higher quality than are currently heard.

Quality of papers and the understandability of the presentations came under heavy attack. It was said that very few talks at meetings were constructive, usually being condensations of a technical paper delivered at high speed and related to a very sophisticated technical problem. The results, it was stated, were that only a few of the audience ever really understand what the speaker says. Most papers presented at technical society meetings were said to be of low quality, largely due to the fact that they were written and accepted primarily for the purpose of gaining funds to attend the meeting, as required by research managers. Papers sometimes are presented to satisfy the ego of the speaker more than to convey anything that is new. Other papers are accepted not because of their quality, but because there are not enough papers submitted, and the session chairman needs to fill in his allotted time period. Papers are often used for commercial purposes, such as to promote a new product, for job hunting, or for contract bidding purposes.

Types of Papers

A considerable portion of our sample interjected criticisms and suggestions involving technical papers to which they have been exposed at meetings. Items relating to this area of concern turned up when our interviewees were asked: "What can be done to improve meetings of scientific and technical societies?" The percentage of mentions is listed below for each suggested item:

	Percent (N=326)
Better selection of papers	25
Better presentation of papers	13
Allow more time for paper presentation	9
Distribution of preprints before meeting	5
Encourage younger or less vocal people to participate by providing funds for their attendance without the need to present papers	4
Train paper presenter in methods and ideas of communication	1
More long review papers, fewer 10-minute talks	1
Eliminate papers	< 1

There was a strong tendency towards improving the selection of papers to be given during a meeting. This was most frequently mentioned by independent laboratories (38%). Mathematicians (13%) expressed the least concern over choice of papers to be delivered.

Most subgroups expressed the feeling that definite steps should be taken towards improving the presentation of papers. The percentage range for several subgroups varied with the total group rate of mention. Examples of this fluctuation are seen within the following subgroups: independent laboratories (21%), industry (19%), university (7%), and mathematicians (3%). In connection with this recommendation, one percent expressed the view that paper presenters should be trained in methods and ideas of communication.

Five percent of our sample recorded the need for more comprehensible paper presentations when asked the question: "What else can be done to improve informal scientific and technical communications in general?". Independent laboratories established the highest rate of mention (12%) among the subgroups .

There is a conflict of opinion concerning the desired length of papers read at scientific meetings. Whereas some attendees call for longer papers, others desire shorter papers (as compared to the 10- or 15-minute papers commonly presented at meetings). There also is a desire for more symposia. At the extreme, a desire was expressed to eliminate papers altogether and to have only pure discussion sessions. Others who favor dispensing with paper reading believe that preprints or copies of the papers should be made available prior to discussions.

Chapter VI

A Questionnaire Study of Informal Scientific and Technological Communications*

Warren R. Graham

This study is a part of a general exploration of the types, functions, and facts concerning informal scientific and technological communications. "Informal communications" were defined for the purposes of this study as those communications that involve personal interactions. Publications produced for public dissemination of information were excluded. This study is concerned only with informal scientific and technological communications behavior.

The area of informal scientific and technological communications behavior is highly complex and diverse, covering many different types of personnel (both scientific and engineering), in many different organizations (both very large and very small), and in many locations (both isolated and urban). The study was designed to obtain information about scientists and engineers based on their own experiences. It is an attempt to explore and to define the nature, roles, boundaries and conditions of informal communications which serve to enhance research efforts. The aim, therefore, is to investigate all possible types of informal scientific communications behavior in a wide variety of situations. It is an effort to learn more about highly unusual modes of informal communication, as well as about relatively commonplace ones. Thus, the primary emphasis is on identification of the

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greatest possible diversity of communications problems and suggested solutions, rather than on the mere establishment of their relative frequencies of occurrence. It is intended that generalizations to the behaviors of national populations of scientists and engineers should be made on the basis of future studies that are specifically designed to provide information suitable for supporting generalizations.

Procedure

In order to obtain information about the informal communications experience of scientists and engineers, a standard interview was developed on the basis of previous user-need studies that had incidentally accumulated information about informal scientific communication. It was decided to limit the interview to one hour in order to insure maximum participation of the researchers who volunteered to help with the study. This decision, however, meant that certain desired information must be eliminated from the preliminary interview form.

In an effort to learn as much as possible about scientists' and engineers' ways, means and purposes in using informal scientific communication, a short questionnaire was developed to supplement the standard interview. The questionnaire emphasized questions concerning quantitative estimates and short-answer questions of fact. The questionnaire was presented at the end of the interview, to be completed and returned at a later date.

Sample

The possibility of searching through directories of professional societies that contain over a million entries for active researchers was an insurmountable task for this project. Therefore, it was decided to limit the number of disciplines and organizations that would be explored by selecting them for the following reasons:

1. To investigate the communications behaviors of scientists from the disciplines of chemistry, physics, biology, and mathematics, and engineers in the major functional technological classifications (i. e., mechanical, electrical).

2. To permit identification of possible differences of problems and behavior between different types of organizations, such as industrial, university, independent, and government laboratories.

Consideration of the ways in which we could explore informal communications behavior made it apparent from the beginning that we would need to use volunteers. It also was apparent that we would need to identify participants by asking research directors and department chairmen to recommend researchers in their organizations whom we could ask to assist with this study. It also was necessary to inform managements of the nature of our operation in order to prevent misunderstandings about our purposes, especially at laboratories involved in operations concerning proprietary or national security.

It was considered necessary to study a variety of scientific disciplines, types of organizations, and geographic locations, and an attempt was made to maximize diversity within small groups. Thus, our sampling procedure was designed to allow us to determine the nature of informal scientific and technological communication behaviors in a wide variety of locations, disciplines, organizations, and situations.

The exploratory nature of the study, and its emphasis on developing methods to study informal scientific communications, did not demand representative samples. In any event, a sample of people that is randomly selected at the beginning of a study will not necessarily provide a random sample when the data are tabulated. Experience has often shown that many individuals in a random sample will not cooperate, and a considerable percentage will drop out for other reasons. The net effect of such attrition usually is to introduce bias into a human sample.

In order to identify the participants required, a sample of research organizations was selected. Those that were chosen gave promise of providing sufficient numbers of scientists and engineers in the desired disciplines. The research organizations were selected from directories of research laboratories and from the card files of the Institute for Applied Technology, National Bureau of Standards, U.S. Department of Commerce, Springfield, Virginia. We also selected universities in geographical areas where there were industrial, independent, and government laboratories that we would visit. In all cases an effort was made to include both large and small laboratories of each kind in each geographical location. The questionnaire was presented to 313 volunteer researchers, but due to attrition, the final sample consisted of 193 scientists and engineers in the following research disciplines:

	N
Chemistry	50
Physics	44
Mathematics	18
Biology	26
Engineering	55

The above scientists and engineers were employed in the following types of organizations:

	N
University	71
Industry	44
Government	61
Independent	17

Comparative Values of Communications Modes

It had been hypothesized that one of the most important values of informal communications to science and technology is its ability to motivate researchers. In order to gain further evidence of the validity of the hypothesis we asked: "Which do you feel stimulates action to complete new research (check one)?

Percentages

	Disciplines					Organizations				
	Chemist	Physicist	Mathematician	Biologist	Engineer	University	Industry	Government	Independent	Total
	N=50	N=44	N=18	N=26	N=55	N=70	N=44	N=60	N=17	N=193
Informal communications	62	68	72	58	84	54	73	88	65	70
Formal communications	28	27	11	34	09	31	20	08	29	22
Both	04	05	06	04	00	06	02	01	06	04
No opinion"	06	00	10	04	07	09	05	03	00	04

Thus, the above percentages show that most researchers (70%) value informal communication very highly for its motivating influence. Only 22 percent felt that formal communications are more important as motivational stimuli.

In order to determine the relative importance of various formal and informal modes of communicating research information, participants were asked to rate a list of them on the following request: "Please rate the following types of communication according to their value to you for providing current information. Designate your rating with the corresponding letter:

Assigned Weight	
3	A = Very valuable.
2	B = Moderately valuable.
1	C = Slightly valuable.
0	D = No value. "

The above indicated unit weights were assigned to each degree of value of a communication in order to provide scalar value estimates for the various groups of researchers. The following approximate value ratings were reported by all participants who completed the experimental questionnaire:

"Moderately valuable" to "Very valuable"

a. Conversations with colleagues here
b. Conversations with colleagues elsewhere
c. Journals

"Moderately valuable"

a. By telephone
b. Books
c. Presentations at seminars
d. Reports from assistants (students)
e. Abstracts
f. Listening to papers at conferences

"Slightly Valuable"

a. Listening to papers at technical society meetings
b. Preprints
c. Letters
d. Memoranda

Mean Values of Communication Modes

	Disciplines					Organizations				All
	Chemist N=50	Physicist N=44	Mathematician N=18	Biologist N=26	Engineer N=55	University N=70	Industry N=44	Government N=60	Independent N=17	Total N=193
Conversations with colleagues here	2.5	2.8	2.3	2.5	2.6	2.4	2.6	2.6	2.8	2.5
Conversations with colleagues elsewhere	2.4	2.5	2.4	2.8	2.6	2.5	2.2	2.8	2.5	2.5
Journals	2.5	2.3	2.4	2.6	2.1	2.3	2.2	2.4	2.5	2.3
By telephone	1.8	1.7	1.7	2.0	2.2	1.8	1.9	2.2	2.3	2.0
Books	2.1	1.9	2.1	2.1	1.9	1.9	1.9	2.1	2.1	2.0
Presentations at seminars	1.8	1.9	1.8	2.3	1.7	1.7	1.7	1.8	2.0	1.9
Reports from assistants (students)	2.1	2.0	1.6	2.2	1.7	2.1	1.8	1.7	1.9	1.9
Abstracts	2.1	1.6	1.4	1.9	1.6	1.8	1.7	1.7	2.0	1.8
Listening to papers at conferences	2.0	1.8	1.3	2.1	1.4	1.9	1.6	1.6	1.6	1.6
Listening to papers at technical society meetings	1.7	1.4	1.2	2.1	1.4	1.6	2.6	1.5	1.6	1.6
Preprints	1.9	1.8	1.5	1.5	1.5	1.6	1.6	1.6	1.8	1.6
Letters	1.6	1.5	1.6	1.5	1.7	1.6	1.3	1.8	1.7	1.6
Memoranda	1.3	1.1	1.3	1.2	1.5	0.7	1.5	1.6	1.9	1.3

Researchers in all disciplines and organizations show a very high degree of agreement on the high value of conversations and journals for providing current information.

There also is a general consistency of magnitudes among the means reported for the several disciplines and organizations for all types of communications listed. But there are several means that are sufficiently deviant to warrant being singled out for special attention. For example, our biologists were an exception in that they rated, "Listening to papers at technical societies" much higher than other disciplines. The same was true for industry researchers, as compared to other organizations. But where chemists and biologists also favored "Listening to papers at conferences," other disciplines gave lower mean ratings. Biologists also rate highly, "Presentations at seminars." Mathematicians rate "Abstracts" quite low, and along with research engineers, they gave low ratings to "Listening to papers at conferences." Chemists and physicists tend to rate "Preprints" more highly than other groups. University researchers showed a low valuation for "Memoranda."

Needs for Funds for Informal Communications

The percentages of responses for the following question are given below: "Consider the organizational funds that you spend for informal scientific and technical communications. Do you (check one):

	Percentages									
	Disciplines					Organizations				All
	Chemist N=50	Physicist N=44	Mathematician N=18	Biologist N=26	Engineer N=55	University N=70	Industry N=44	Government N=60	Independent N=17	Total N=193
Receive enough?	50	41	39	39	56	33	57	51	59	47
Need somewhat more?	32	39	50	35	24	40	25	33	29	33
Need much more?	10	16	00	23	11	20	07	10	06	12
No opinion?"	10	08	11	03	09	07	11	06	06	08

About 45 percent of researchers in general indicate that they need more funds for informal communications, and 12 percent say that they need much more funds for this purpose. The need for more funds appears to be most generally felt among physicists (55%) and biologists (58%), and especially among researchers on university faculties (60%).

Payoffs from Informal Communications Costs

Another question produced the percentages below concerning funds for informal communications. The question was: "Consider the payoffs from organizational money spent on informal communications. Are the costs (check one):

	Percentages									
	Disciplines					Organizations				All
	Chemist N=50	Physicist N=44	Mathematician N=18	Biologist N=26	Engineer N=55	University N=70	Industry N=44	Government N=60	Independent N=17	Total N=193
Much too high?	00	00	00	04	02	01	02	00	00	01
Moderately high?	18	16	00	15	24	11	18	19	29	17
Fairly low?	42	54	44	35	49	50	48	44	35	46
Very low?	28	25	39	35	18	27	18	33	24	26
No opinion?"	12	05	17	11	07	11	14	04	12	10

Thus, it appears that of researchers in general, only one percent consider costs of informal communications to be much too high, and only 18 percent consider costs to be high at all. Researchers employed in independent laboratories are especially prone to rate informal communication costs as high (29%), while those employed in universities are much less apt to rate such costs as being high (12%).

Needs for Time for Informal Communications

The responses to the experimental questionnaire give the following percentages of responses to this question: "In terms of the time you spend on informal scientific and technical communications, do you (check one):

Percentages

	Disciplines					Organizations				All
	Chemist N=50	Physicist N=44	Mathematician N=18	Biologist N=26	Engineer N=55	University N=70	Industry N=44	Government N=60	Independent N=17	Total N=193
Have enough time?	46	43	50	31	36	39	48	34	53	41
Need somewhat more time?	44	39	28	50	53	46	45	45	41	45
Need much more time?	10	16	22	19	11	14	07	22	6	14
Have no opinion?"	00	02	00	00	00	01	00	00	00	1

Fifty-nine percent of researchers in general reported a need for more time for informal communications. About 14 percent reported that they "Need much more time," and this degree of expressed need appears to be greatest in government organizations (22%), but least among researchers in industry (7%).

An attempt was made to obtain a quantitative estimate of the value of time spent on informal communication through the following rating question: "Consider the payoffs from time spent on informal scientific and technical communications. Are the costs in time (check one):

	Percentages									
	Disciplines					Organizations				All
	Chemist	Physicist	Mathematician	Biologist	Engineer	University	Industry	Government	Independent	Total
	N=50	N=44	N=18	N=26	N=55	N=70	N=44	N=60	N=17	N=193
Much too high?	08	<1	<1	<1	<1	03	02	02	<1	02
Moderately high?	26	29	39	23	27	24	25	32	35	28
Fairly low?	50	48	50	54	53	57	57	43	35	51
Very low?"	16	18	11	23	20	14	16	21	29	18

Most raters (69%) consider costs in time to be low, and only two percent indicate that time used for this purpose is "much too high."

Expenditures for Informal Communications

In an effort to estimate the monthly average cost per researcher for informal communications, the following question was asked: "About how much of your organization money do you spend each month for informal scientific and technical information by:

	Mean Number of Dollars
Telephone	10
Travel for personal discussions	13
Letters and memoranda	19
Pre-publication drafts	8
Technical society meetings"	14
Total	$64

Thus, the researchers who completed the experimental questionnaire were able to estimate their direct monthly expenditures. The mean numbers of dollars amount to an approximate average of $768 per year, as a rough gross estimate of project directors' current expenditures for informal scientific communications.

<u>Preprints</u>

An attempt was made to get a rough estimate of the number of preprints that researchers send and receive with the following question: "How many copies of preprints do you mail each year?" The mean number of preprints mailed in a year was 38, or less than one preprint per researcher, on the average.

Conversely, we also asked: "About how many copies of preprints do you receive each year?" The mean number received was 32, again less than one preprint per researcher on the average.

In an effort to elaborate information about the use of preprints, we asked: "Are you in favor of developing further the distribution of preprints?"

The following percentages were obtained:

	Percentages									
	Disciplines					Organizations				All
	Chemist	Physicist	Mathematician	Biologist	Engineer	University	Industry	Government	Independent	Total
	N=50	N=44	N=18	N=26	N=55	N=70	N=44	N=60	N=17	N=193
Yes	52	45	33	31	44	43	48	45	29	44
No	46	48	44	46	36	47	39	36	65	44
No opinion	02	07	23	23	00	10	13	19	06	12

The percentages of participants who are in favor of developing further the distribution of preprints equals the percentage who are not in favor of greater distribution (44%). Chemists most frequently indicated a favorable attitude (52%), whereas mathematicians and biologists generally were unfavorably inclined toward greater use of preprints (33% and 31%, respectively).

Newsletters

An approximation of the use of newsletters was sought through the following question: "Do you receive an informal newsletter concerning activities of your field of specialization?"

	Disciplines					Organizations				All
	Chemist	Physicist	Mathematician	Biologist	Engineer	University	Industry	Government	Independent	Total
	N=50	N=44	N=18	N=26	N=55	N=70	N=44	N=60	N=17	N=193
Yes	44	36	56	58	64	41	50	60	53	51
No	56	64	44	42	34	59	48	40	47	49
No opinion	00	00	00	00	02	00	02	00	00	00

Percentages

Thus, approximately as many researchers do not receive a specialized newsletter as receive one (51% and 49% respectively). A greater proportion of engineers appear to use newsletters (64%) than occurs in other disciplines, e. g., physicists (36%). And a higher rate of use is reported for government researchers (60%) than for university faculty members (41%).

We also inquired about the values placed on newsletters by researchers, asking, "Do you find newsletters to be valuable?", with the following results:

Percentages

	Disciplines					Organizations				All
	Chemist	Physicist	Mathematician	Biologist	Engineer	University	Industry	Government	Independent	Total
	N=50	N=44	N=18	N=26	N=55	N=70	N=44	N=60	N=17	N=193
Yes	50	54	50	35	60	37	59	60	59	52
No	24	25	11	35	21	30	23	16	29	24
No opinion	26	21	39	30	01	33	18	24	12	24

Although a slight majority find newsletters to be valuable (52%), about 24 percent do not value them. The fact that another 24 percent did not choose to express an opinion, however, indicates that there may be considerable room for improvement of newsletter services.

Visits and Exchanges

Because of the high costs of visits as well as of meeting and conference attendance, we asked the following question concerning visits made each year: "How often do you visit out-of-town laboratories to discuss scientific and technical problems?"

Mean Number of Visits

Disciplines					Organizations				All
Chemist	Physicist	Mathematician	Biologist	Engineer	University	Industry	Government	Independent	Total
N=50	N=44	N=18	N=26	N=55	N=70	N=44	N=60	N=17	N=193
6.2	5.2	5.2	6.6	4.4	5.4	4.6	6.6	3.1	5.5

As was the case for attendance at meetings, researchers in independent laboratories also report the smallest average number of visits. Research engineers report the lowest average among the disciplines.

With respect to exchanges among researchers as a special type of visit, we asked the following question: "During the past two years, has your organization granted you a leave of absence to accept an appointment elsewhere?" We found the following percentages of researchers who were granted leaves-of-absence:

Percentages

	Disciplines					Organizations				All
	Chemist	Physicist	Mathematician	Biologist	Engineer	University	Industry	Government	Independent	Total
	N=50	N=44	N=18	N=26	N=55	N=70	N=44	N=60	N=17	N=193
Yes	<1	01	33	<1	<1	10	05	09	06	08
No	94	89	67	[illegible]	94	89	93	90	88	90
No response	05	10	00	07	06	01	02	01	06	10

In contrast to the other disciplines which showed less than one percent having a leave of absence during a two-year period, mathematicians showed a very high percentage of leaves-of-absence for appointments elsewhere (33%). Industry and independent laboratory personnel were granted such leaves in the smallest proportions (5% and 6%, respectively). On the whole, very few researchers reported being granted temporary leaves-of-absence for scholarly exchanges during a two year period (8%).

Monthly Society Meetings

An attempt was made to estimate the depth of opinion concerning monthly meetings. Listed below are the percentages writing in answers to the following question: "Would it be to your advantage to have available monthly meetings of a professional society in your field?":

	Percentages									
	Disciplines					Organizations				All
	Chemist N=50	Physicist N=44	Mathematician N=18	Biologist N=26	Engineer N=55	University N=70	Industry N=44	Government N=60	Independent N=17	Total N=193
Yes	38	32	33	54	42	37	45	40	35	39
No	36	54	50	38	36	51	25	38	59	42
Probably	04	04	06	08	09	01	11	03	00	04
Doubtfully	02	02	06	00	03	01	02	05	00	03
No opinion"	20	08	05	00	10	10	17	14	06	12

It appears from the above result that there is a very evenly balanced difference of opinion for researchers in general concerning the value of available monthly professional society meetings, as they are currently known to be structured. Biologists, however, are much more in favor of such meetings (54%) as compared to researchers in general (39%). Among those groups most unfavorably inclined toward monthly meetings are physicists (54%) and mathematicians (50%), as contrasted to researchers in general who said "No" (42%). Among organizational groups, the independent laboratories produced the greatest percentage of "No" answers (59%), followed by university researchers (51%).

In an effort to estimate the average meeting attendance rate, the following question was asked: "About how many meetings of scientific and technical societies do you attend each year?", with the following result:

Mean Number of Meetings

	Disciplines				Organizations				All
	Chemist	Physicist	Mathematician	Biologist	Engineer	University	Industry	Government	Independent	Total

Chemist	Physicist	Mathematician	Biologist	Engineer	University	Industry	Government	Independent	Total
N=50	N=44	N=18	N=26	N=55	N=70	N=44	N=60	N=17	N=193
4.7	3.7	3.8	4.5	4.0	3.9	4.8	4.5	2.1	4.1

It is apparent from the above averages that scientists employed in independent laboratories on the average attend the fewest number of meetings each year.

Restriction on Communication

Discussions concerning research sometimes are limited by national security considerations, proprietary interests, or individual needs for priority of publication. In order to gain a rough insight into the general effect of such constraints on information exchange, we asked the following question: "Are you reluctant to discuss your new research plans with people outside of your own laboratory or department?" The following percentages of positive and negative answers were recorded:

	Percentages									
	Disciplines					Organizations				All
	Chemist	Physicist	Mathematician	Biologist	Engineer	University	Industry	Government	Independent	Total
	N=50	N=44	N=18	N=26	N=55	N=70	N=44	N=60	N=17	N=193
Yes	42	23	11	23	36	26	55	20	24	31
No	58	77	78	77	64	74	45	79	71	68
No opinion	00	00	11	00	00	00	00	01	05	01

About two-thirds of our respondents stated that they are not reluctant to discuss their new research plans with researchers outside of their own laboratories. Almost one-third revealed that they are reluctant, but many of these researchers indicated that their reluctance would extend only to certain individuals or groups.

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Chapter VII

An Investigation of Incidents of Informal Scientific and Technological Communications *

Warren R. Graham**

This study was undertaken to acquire information about the actual behavior of scientists and engineers while engaged in communicating information concerning their work. The plan was to observe the efforts of scientists and engineers to exchange information as they occurred. It was expected that the data obtained would provide initial estimates of the relative importance and value of results that accrue from informal scientific and technological communications. Several questions that led to the decision to obtain data based on reported incidents of communication as they occurred were as follows:

1. What actual purposes are served by informal scientific and technological communications, and how are they used?

2. What is the importance of information communications:

   a. scientifically?
   b. economically?
   c. motivationally?
   d. innovationally?

3. Approximately how much professional time and money is spent on informal scientific and technological communications?

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** The briefings that made this study possible were conducted by John Skalski, John Delaney, Ernest Brett, Clinton Wagner, William Gloege and Martha Ayres.

The primary purpose of this study, therefore, was to make an exploration of researchers' informal communications behavior in order to learn what is done, how it is done, and why.

Procedure

Since this was an exploratory methodological study , and generalizations to populations such as that above were not intended, randomly representative samples were not required. Rather it was desired to maximize the variety of incidents reported. This was done by using about 40 subjects in each major discipline having about 10 drawn from each type of organization. But such a sample probably is no less representative than the remnants of an initially random sample that has been depleted by the sources of attrition that usually affect human samples.

The sample was selected by identifying research laboratories and universities in the eastern United States (Chicago, Buffalo-Rochester, Boston, New York, New Jersey, Washington-Virginia-Maryland). The laboratories used were selected because they employed researchers of the following types:

Chemists and Biochemists
Physicists
Mathematicians
Microbiologists and Physiologists
Mechanical, Aerospace, and
Electronic Engineers

The laboratories visited were in the following types of organizations:

University
Industry
Government
Independent

Table 1 presents the percentages of incidents received by discipline and by type of organization:

Table 1

Percentages of Incidents by Type of Initial Contact
(N = 1830)

	No. of Memos	Percent
Disciplines		
Chemists	425	23
Physicists	385	21
Mathematicians	152	08
Biologists	230	13
Engineers	638	35
Organizations		
University	482	26
Industry	565	31
Government	647	35
Independent	136	07

Participants who returned Communications Incidents Memos indicated 20 different classes of persons with whom they communicated about research, as shown in Table 2. Sixteen of these classes account for at least one percent of the 1, 830 incidents and taken together they account for 96 percent. The most frequent persons communicated with were coworkers (36%), especially among industry researchers (47%), but less so among government researchers (29%). About 13 percent of the incidents reported occurred during group or joint activities, especially those received from government researchers (19%).

Table 2

Percentages* of Types of Communicators

	Disciplines: Chemists	Physicists	Mathematicians	Biologists	Engineers	Organizations: University	Industry	Government	Independent	Total
Incidents Reported	425	385	152	230	638	482	565	647	136	1830
Types of Communicators:										
Coworker in same section	40	34	35	34	35	33	47	29	43	36
Group in same section	16	14	13	9	14	8	11	19	7	13
Supplier or mfrs. rep.	7	7	1	5	11	5	7	10	4	8
Scientist at outside facility	5	10	5	10	4	11	4	6	8	7
Supervisor	8	6	4	1	6	2	8	5	9	6
Consultant	3	3	7	5	5	1	4	8	2	4
User or sponsor's repr.	3	3	5	1	5	1	6	4	3	4
Visitor from outside facility	2	5	3	10	2	5	2	5	2	4
Author	1	3	3	6	3	5	2	3	1	3
Scientist in other section, etc.	2	2	5	3	3	2	3	3	2	3
Graduate student	1	2	6	1	1	6	1	-	1	2
Director or mgr. (org. level)	1	2	-	2	1	1	2	1	1	2
Student or tech. assistant	4	1	1	3	1	8	-	-	1	2
Editor	1	1	1	2	1	3	-	1	-	1
Speaker	2	1	3	-	-	3	1	-	5	1
Meeting or confer. attendee	1	-	3	-	1	1	1	-	2	1
Computer programmer	-	-	-	-	-	-	-	-	-	-
Librarian or infor. specialist	-	-	-	-	-	-	-	-	-	-
Contractor or sub-contractor	-	-	-	-	-	-	-	-	-	-
Supervising tech. specialist	-	-	-	-	-	-	-	-	-	-

* Cells without data represent less than one percent of incidents reported.

Each prospective participating researcher was visited by a staff representative who explained the purpose of the study and obtained his cooperation. A follow-up letter requesting return of accumulated Memos was sent each week to each of 313 researchers who agreed to participate. In all, 1830 incidents were recorded and submitted by 180 participant observers who returned at least one incident in business reply envelopes provided for that purpose. There were, in addition, an unknown number of active participants who were not able to report at least one incident.

The procedure required researchers to record their daily activities concerned with informal scientific and technological communications for a period of one month. A Scientific and Technological Communication Incidents Memo form consisting of a single page was developed and used for recording the observations over a period of one month for each researcher. The form provided for a description of an incident in the following terms: (a) length of time required, (b) location of the occurrence of the incident, (c) the cost to complete the incident, (d) an abstract of what occurred, and why, (e) the results of the incident, and (f) a rating of its value to the observer on a four-point scale (Exceptional, High, Moderate, Useless, Unknown). Participants were instructed to write down incidents as soon as possible after they occurred. Thus, the participating researchers observed and reported incidents in approximate real time, thereby minimizing the effects of forgetting and other possible distortions of events.

The incidents were categorized according to the contents of the Incidents Memos abstract. The categories were determined rationally in terms of the functional meaning of the incident abstracted on the form. The categories of abstracts are: research planning, methods and techniques, data evaluation, materials and equipment, acquired information, and guidance of students or assistants. Each abstract was reviewed and coded according to a category statement of its content (within each of the above broad categories). Upon completion of the coding, data were tabulated in terms of five different disciplines and in terms of four different types of organizations. In order to illustrate the types of incidents that were reported, the following 10 abstracts were prepared:

1. The need to obtain the use of scientific equipment by informal means was shown in an observation concerning a visit by a scientist to another laboratory. A discussion of research programs concerning high magnetic fields led to permission for the observer to use high magnetic fields generated at the laboratory he visited. The scientist rated the value of his information communication "High."

2. Another observation concerns the value of a telephone call to a consultant by a scientist in a biological laboratory. The call concerned chimpanzee specimens suspected as a source of infectious hepatitis contracted by a veterinary. As a result, a transfer was made of both prebleeding and convalescent sera specimens from the chimpanzee, and also sera from the veterinary for assay. The researcher rated the value of his informal communication "Exceptional."

3. A university researcher reported that he gave an informal talk on nuclear physics to a college physics department. His talk led to a reexamination of their proposal concerning a $100,000 purchase. He rated the value of his informal communication as "Exceptional."

4. Another illustrative observation concerns a conversation between a scientist and a journal editor. The scientist mentioned a proposed task he was about to start, and the editor pointed out that his basis for the proposal had been superseded by later results that were not yet published. The editor supplied the latest findings and the scientist modified his proposed program. This scientist also rated the value of his informal communication "Exceptional" for obvious reasons.

5. A government scientist spoke with a coworker who had attended an importantsymposium. The scientists obtained very valuable information in connection with his rocket-popellant program. This information led to several new possibilities in improved formulation to be evaluated. ("Exceptional").

6. Another government scientists discussed recent data on magnetostriction in garnets with a coworkers, with the ("Exceptional") result that a new program was formulated.

7. A university physicist had an idea on how to fix troubles in malfunctioning spark chambers by changing the design. He talked about his idea with a coworker. They tried it and it worked. ("Exceptional").

8. A university chemist dropped in to view a colleague's scintillation counter and was shown how this apparatus could be used in his own work. The result led to their cooperating in a joint research effort ("Exceptional").

9. A government scientist was brought some recently obtained traces on Brillouin scattering in CO_2 near the critical point. The traces were provided by a university physicist who requested help in borrowing a laser in order to continue his work. The desired help was promised. ("High").

10. A universitv mathematician learned that a method of setting up difference equations to solve a particular problem had been used successfully. The method had seemed very unlikely on its face and the information is not yet published. The participant felt the incident provided "quite significant" information to him and he rated it "High."

Types of Incidents Content

The Communications Incident Memo data show that researchers in a wide variety of disciplines and types of organizations use informal communications for the same general purposes, and with the same general results. The percentages of communications purposes recorded as content of abstracts of incidents are summarized in Table 3 by discipline. With a few noteworthy exceptions, the patterns of disciplines and organizations are highly similar in terms of purposes of use of informal communications.

Table 3

Percentages of Memos by Content of Abstracts

		Content of Abstracts					
	Number of Memos	Research Planning	Methods & Techniques	Data Evaluation	Materials & Equipment	Acquiring information	Guidance & Supervision
Disciplines							
Chemists	425	24	21	21	17	17	01
Physicists	385	25	20	24	13	17	02
Mathematicians	152	30	18	24	01	24	02
Biologists	230	34	13	28	08	25	01
Engineers	638	25	27	27	18	13	01
Organizations							
University	482	22	18	22	12	22	04
Industry	565	26	26	20	08	13	<01
Government	647	27	20	20	15	17	<01
Independent	136	36	24	21	13	15	<01
Total	1,830	27	22	20	14	17	01

The percentages in Table 3 show that informal communications are used by all researchers most frequently in the beginning phases of research as a means to developing plans (27%). It appears to be especially true for biologists (34%) and for scientists employed in independent laboratories (36%). A related use of informal communications by scientists in general is to develop methods and techniques for carrying out their research plans (22%), especially in engineering (27%), but not with great frequency in biology (13%).

Another point at which researchers' informal communications are brought heavily into play is near the end of a research project for data evaluation purposes (20%). Greatest frequencies of occurrence of data analysis use of informal communications are shown for biologists (28%) and engineers (27%).

Materials and equipment problems are also dealt with by informal means, as reported in 14 percent of the Memos returned. As is to be expected, mathematicians rarely report activities involving materials or equipment (1%), and biologists also show a smaller frequency than those in other disciplines (8%). Researchers employed in industry also use this category at a lower frequency than researchers in other types of organizations (8%).

The fifth major content category of use of informal communications is to acquire general scientific and technological information not directly related to the conduct of a particular research (17%). The current-awareness aspect of use of informal communications is most often reported by mathematicians (24%), biologists (25%) and researchers employed in universities (22%). Engineers apparently place a lesser amount of emphasis on current awareness information than other disciplines (13%).

Type of Results

Table 4

Percentages of Memos by Type of Result

	Number of Memos	Result of Incident					
		Research Planning	Methods & Techniques	Data Evaluation	Materials & Equipment	Acquiring Information	Motivation
Disciplines							
Chemists	425	12	08	09	07	16	07
Physicists	385	20	08	10	06	19	11
Mathematicians	152	12	09	07	01	20	09
Biologists	230	18	04	11	05	21	11
Engineers	638	17	11	11	09	23	10
Organizations							
University	482	10	08	< 01	06	19	10
Industry	565	19	09	< 01	06	21	08
Government	647	18	09	10	09	20	11
Independent	136	21	11	< 01	05	31	07
Total	1,830	16	08	10	07	21	09

With respect to the results of an informal research communications, a considerable frequency were reported on our Memo as "Unknown" (12%).

Table 4 shows that there again is a similarity of patterns among disciplines and types of organizations with respect to the kinds of results that accrued from informal communications. There also are some noteworthy exceptions. Acquiring information was the most frequently reported outcome of an informal research communication reported by researchers in general (21%) but least frequently by chemists (16%). Researchers employed in independent laboratories report acquisition of information as a result with a very high frequency (31%).

The second most frequently mentioned result of an informal communication is a contribution to the development of a research plan (16%), especially on the part of physicists (20%). Much lower frequencies of planning contributions were reported by chemists (12%) and mathematicians. There also are differences among types of organizations concerning research plan development as a result, ranging from a small frequency of incidents reported by university researchers (10%) to a much larger frequency reported by those in independent laboratories (21%).

About 10 percent of our researchers reported a ontribution to evaluation of data as a Result. There appears to be a possible major difference between researchers employed in government organizations (10%) and those in the other three types of organizations where less than one percent reported incidents in the Data Evaluation category.

The remaining categories in which incident results were reported by researchers in general are Methods and Techniques (8%), Materials and Equipment (7%) and Motivation (9%), none of which show unexpected variations among disciplines and types of organizations.

Rating of Values of Informal Communications

The last information provided on the Communications Incident Memos was a rating of the value of the informal communication reported. Table 5 shows that experimental researchers reported less than one percent of their communications incidents as "Useless," and mathematicians rated only two percent as being in this category.

Table 5

Percentages of Memos Assigned to Each Rating Category

	Number of Incidents	Value Rating: Useless	Moderate	High	Exceptional	Unknown
Disciplines						
Chemists	425	<1	33	47	10	8
Physicists	385	<1	35	39	11	14
Mathematicians	152	2	36	43	5	15
Biologists	230	<1	28	44	17	10
Engineers	638	<1	36	44	10	8
Organizations						
University	482	1	34	39	11	15
Industry	565	1	36	49	10	4
Government	647	< 1	33	42	12	12
Independent	136	2	33	47	10	7
Total	1,830	2	34	44	11	10

Mathematicians also differed from experimenters in rating only five percent of their incidents as "Exceptional," whereas experimenters in other disciplines rated from 10 to 17 percent of their incidents as having exceptional value. The value of 17 percent occurs for biologists who appear to use higher ratings for their informal communications than other researchers.

Ratings of "High" were assigned to 44 percent of the reported incidents, within a narrow range from 39 to 47 percent for disciplines and organization types. There is similar consistency around the 34 percent point for ratings of "Moderate," except for biologists who used this category for only 28 percent of their incidents.

The figures in Table 5 should be interpreted as minimum percentages since at the time of rating 10 percent of the incidents were classified as of "Unknown" value, but are included in the 1,830 incidents on which the percentages are based. There appears to be little doubt that our researchers value their informal communications very highly, and that informal communications contribute substantially to research progress.

Research Planning

A number of kinds of informal research communications are classified as abstracts of research planning activities. Although each type of communication occurs with a relatively low frequency of mention, when taken together they account for 27 percent of the incidents reported by all participant researchers.

Abstract Content Research Planning	Percent of Incidents (N = 1, 830)
Progress and requirements of projects	6
Future theoretical and experimental activities	5
Factors relating to a proposal	4
Review of a manuscript	4
Review of purpose, concepts and meanings	3
Discussion of start of a project	2
Plans for tests	1
Review of patent coverage	<1

The results of the informal planning communications, when taken together, account for about 16 percent of the incidents reported, as follows:

Results Research Planning	Percent of Incidents (N = 1, 830)
Research problems cited and defined	3
Formulated new ideas for research	2
Solution to a problem suggested	2
Scope of a study and options agreed on	2
New program recommended	2
New research areas identified	1
Modified an existing program	1
Prepared a proposal	1
New schedule developed	1
Developed a theoretical approach	< 1
Misconceptions clarified	< 1

Methods and Techniques

Intimately related to research planning activities are informal communications that apply specifically to the methods, procedures, techniques and designs required to carry out the research effort. About 22 percent of all incidents abstracts were classified under this general heading.

Abstract Content Methods and Techniques	Percent of Incidents (N = 1, 830)
Ways to solve a given research problem	5
Criticism or correlation of techniques	4
How to run tests	3
Methods of measurement	2
Underlying principles and limitations	2
New device and its design	2
Value of a new product	2
Feasibility of modification	1
Use of theoretical models	< 1

The results of discussions on methods and techniques are of low frequency of mention and account for 8 percent of the incidents reported.

Results Methods and Techniques	Percent of Incidents (N = 1, 830)
Clarified obscure points or problem	2
Concluded methods were valid	2
Developed novel method or procedure	1
Method found to be inadequate	1
Found research is not feasible now	1
Selected model for a new theoretical analysis	<1
Agreed on a technique of lab analysis	<1
Engineering specifications to be published	<1

Evaluation of Data

A third important use of informal communications among researchers concerns evaluation of research data. This category accounts for 20 percent of the abstracts submitted by researchers in general. The applications of informal communications in evaluating data were as follows:

Abstract Content Evaluation of Data	Percent of Incidents (N = 1, 830)
Analysis of data and results	7
Requesting data from another researcher	5
Discussion of a previous related experiment	3
Presentation of preliminary evaluative data	2
Discussion of draft of technical paper	2
Analysis of discrepancies and inaccuracies	1

Results of discussions concerning data evaluation were reported for 10 percent of the incidents, as follows:

Results Evaluation of Data	Percent of Incidents (N = 1,830)
Further analysis or processing undertaken	5
Suggested techniques now under consideration	2
Solved the problem	1
Errors detected and corrected	<1
Increased system's output of useful data	<1
Modified a design	<1
Other results found to support theory or idea	<1
Research product identified	<1

Materials and Equipment

The materials and equipment that are indispensable to the conduct of a research came in for a fair share of notice as abstracts reported of incidents by 14 percent of the researchers in general. Their percentage rates of incident reports were as follows:

Abstract Content Materials and Equipment	Percent of Incidents (N = 1,830)
Availability and cost of supplies	3
Equipment needs	2
Testing of materials	2
Relation between design and performance	2
Adequacy of materials	1
Modification of equipment	1
Fabrication of equipment	1
Calibration of equipment	<1
Testing of equipment	<1
Accuracy of instruments	<1
Accuracy of standards or compounds	<1
Trouble shooting	<1

The results of communications about materials and equipment account for seven percent of the incidents received from researchers in general. Although the results that are reported appear to be of major importance to research progress, their frequencies of mention were quite low, as follows:

Results Materials and Equipment	Percent of Incidents (N = 1, 830)
Agreed on equipment required	3
Determined if required supplies were available	1
Found other materials could be used	< 1
Concluded sample not suitable	< 1
Obtained help to use equipment better	< 1
Purchase instrument evaluated as best	< 1
Reorganized equipment for greater efficiency	< 1
Found equipment was not flexible enough	< 1
Reduced time required in using equipment	< 1
Proposed to conduct tests at available facility	< 1

Acquiring Information

Another important area in which informal communications were mentioned with considerable frequency concerns attempts to acquire information. Acquisition of information accounts for 17 percent of the incidents reported by researchers in general, as follows:

Abstract Content Acquiring Information	Percent of Incidents (N = 1, 830)
State of the art, current awareness	7
Problems of mutual interest discussed	6
Conference on possible product applications	2
Request for details of cost and performance	1
Representative presented experience and capabilities	1
Checked validity of claims for a product	< 1
Final draft completed	< 1

The results of efforts to acquire information were reported in 21 percent of the incidents as follows:

Results Acquiring Information	Percent of Incidents (N = 1,830)
Increased knowledge about the state-of-the-art	5
Better understanding of the work of others	3
Pertinent information acquired and used in design of a study	2
Greater weight into the nature of an experiment	2
Requirements were clarified	2
Better feel for the task background	1
Conference on design problems	1
Clarification of a basic misunderstanding	<1
Changes in interpretation were suggested	<1
Saved much additional investigation	<1
Determined modification feasible at moderate cost	<1
Learned that a publication had been superseded	<1
Important unpublished information obtained	<1
Obtained improvement on a paper to be presented	<1
Learned where information is published	<1
Learned about other activities in my field	<1
Verified accuracy of information	<1
Obtained information about systems' capabilities	<1
Learned of university program in our field of interest	<1
Knowledge of suppliers' operations	<1
Obtained help of outside technical experts	<1
Informed visitor of our activities in his field	<1

Motivation

Nine percent of the informal communications incidents reported increased motivation as a result, as follows:

Results Motivation	Percent of Incidents (N = 1, 830)
Collaboration was undertaken	4
Suggestion encouraged investigation	2
Gained constructive suggestions or insights	2
Became aware of mutual interests	<1
Curiosity aroused by idea that an experiment was possible	<1
Measurement insensitivity stimulated developing a new method	<1

Miscellaneous Results

Results Miscellaneous	Percent of Incidents (N = 1, 830)
Revised galley proofs of publication	1
Received an invitation to visit a lab	1
Publication of a manuscript	<1
Received information enclosed in a letter	<1

Table 6

Percentages* of Types of Informal Communications

	Disciplines	Chemists	Physicists	Mathematicians	Biologists	Engineers	Organizations	University	Industry	Government	Independent	[illegible]
Incidents Reported		425	385	152	230	638		482	565	647	136	1[illegible]30
Types of Communications												
Conversation (individual)		30	36	34	28	33		39	37	24	29	32
Office conference		23	19	23	22	25		13	23	31	21	23
Telephone call		21	18	12	21	21		16	19	23	20	19
Conference of specialists		4	6	6	5	2		3	5	4	4	5
Seminar or colloquium		5	3	8	4	3		10	1	2	4	4
Letter		4	5	4	3	2		5	2	5	1	4
Memorandum		4	2	1	-	-		1	3	1	3	2
Pre-publication		2	2	5	1	2		5	2	1	2	2
Visit to outside facility		-	2	2	2	1		1	1	2	1	2
Proposal		-	-	-	2	1		1	1	2	1	1
Journal article		1	-	1	2	2		2	-	3	1	1
Society meeting		2	1	-	1	2		2	1	-	4	1
Luncheon or dinner		-	1	1	2	-		1	1	-	2	1
Accidental encounter		-	-	-	-	-		-	-	-	-	-
Project progress report		-	-	-	-	-		-	-	-	-	-
Dissertation defense		-	-	-	-	-		-	-	-	-	-
Radio contact		-	-	-	-	-		-	-	-	-	-
Technical advertisement		-	-	-	-	-		-	-	-	-	-
Trade or design show		-	-	-	-	-		-	-	-	-	-
Specification		-	-	-	-	-		-	-	-	-	-

* Cells without data represent less than one percent of incidents reported.

Types of Informal Communications

What are the most used modes of informal research communications? The Communications Incidents Memo requested the participants to classify their communications by "Type of Communication" on a checklist. Tabulations of responses to the checklist resulted in the percentages presented in Table 6. About 32 percent of the reported incidents of informal research communications were accomplished by individual conversations and 23 percent were the result of an office conference. Table 6 indicates several notable exceptions, however, since incidents reported by government researchers show percentage figures almost in the reverse of those for all incidents (24 percent for conversations and 31 percent for office conferences). Incidents from universities indicate very light use of office conferences (13%), but this is counterbalanced by greater use of seminar and colloquium conferences (10%).

It is especially interesting to note that only one percent of the incidents reported on communications during society meetings and only two percent reported on visits to an outside facility. With respect to printed materials, only two percent of the informal communications incidents involved preprints and only two percent involved journal articles.

The first 13 modes of informal communication listed (for one percent or more of the incidents) cover 97 percent of all incidents reported.

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Chapter VIII

Problems and Recommendations

Warren R. Graham

We have explored the field of informal research communications in order to define its boundaries, functions, and values. The data contain many implied as well as stated problems that deal with ways to advance research productivity by improving informal research communications. It is a valued characteristic of exploratory studies to raise questions for future investigation. An exploratory effort should make it possible to identify the relevant problems and to frame questions that can be answered.

This section of the report contains statements of problems uncovered during our study. They are problems that appear to be solvable, providing decisions are made about actions to be taken by the government.

The study reported herein was undertaken as a precursor to a nationwide survey of research scientists and engineers suggested by COSATI. It should not be surprising, therefore, that many of the recommendations that follow concern needed intensive studies that can now be carried out on the basis of data contained in this report.

Communication Technology

A constantly recurring theme in our interviews concerns expressions of a need for improved utilization of communications technology in the service of science and engineering research. A number of problems dealing with various types of electronics devices and related modes of informal communications were called to our attention.

Problem: Many scientists stated that they are not permitted to use the telephone for research business calls as often as they feel that they should. The telephone was seen as one of the most effective and inexpensive means of enhancing research through informal communications, but administrative restrictions often exist on use of the telephone communications network. The telephone was reported to be most effective as a substitute for highly expensive and time-consuming long distance travel. Under conditions of emergency restrictions on travel funds, long distance telephone service was seen as even more vital to research progress than during normal times. The telephone problem does not exist to the same degree in military organizations as elsewhere, where there is access to the Defense Department AUTOVON telephone system, or in large corporations that have nationwide leased-line systems. A need for more s amble phones for classified discussions also was reported.

Recommendation: That telephone use for long distance research communications be made available without restraints to directors who are responsible for the progress of research projects. More funds should be budgeted for telephone use, both as a means of conserving travel funds and to speed research progress.

Problem: When tables, diagrams, charts or parts must be involved in a research discussion, the telephone is inadequate. Visual stimuli are needed in order to communicate with the detail and precision required by research scientists and engineers.

Recommendation: That a communications systems study be made on research communications facilities and financing, with a view toward establishing a nationwide communications network for research scientists and engineers.

Problem: Telephone communications often require documentary confirmations, but mail follow-ups often are too slow.

Recommendation: That an investigation be made of teletype and night letter research communications (wherever they are now accessible to researchers) and that the results be incorporated into the above recommended systems study of telephone communications.

Television and Recording Facilities

Problem: Many researchers who wish to attend distant meetings and seminars cannot do so because of time and cost limitations. In particular, a need was expressed to hear presentations of prominent invited speakers at meetings and conferences when they discuss topics in specialties of research interest.

Recommendation: That the possibility of establishing closed circuit television broadcasts be studied as a potential means of increasing audience sizes (including the possibility of setting aside UHF, satellite and closed circuit TV channels).

Problem: Once a distinguished speaker's lecture has been delivered at a meeting, it usually is no longer available for other purposes, such as for training students and updating other researchers. There is a need to have valuable speeches and proceedings recorded, preserved and reproduced for dissemination to wider audiences.

Recommendation: That a feasibility study be made to determine if technological and cost problems can be overcome for establishing an audio and video tape library system for recording and preserving speeches and proceedings concerning research specialties.

Visits

Although it was frequently acknowledged that a telephone conversation often can be used as a substitute for a visit, nevertheless this is not always the case. The principal exceptions concern the need to try out laboratory equipment and to study equipment set-ups that have been built for special types of research. The discussions that center around materials and equipment frequently lead to new ideas for research procedures, permission to use available equipment, and to adaptations of equipment to new purposes.

Problem: The fundamental reasons for making visits to other laboratories frequently are not adequately comprehended and permission to travel often is withheld to the detriment of research progress. Visits to other laboratories for the purpose of studying equipment and equipment set-ups fill a fundamental need for information that is required to advance research productivity.

Recommendation: That a study be made of researchers' requirements to visit other laboratories, including organization of a nationwide system of low-cost travel tours to selected laboratories.

Problem: No adequate substitute for visiting other laboratories is now available when visual study of their facilities is desired.

Recommendation: That a study be undertaken with a view toward establishing a continuing, up-to-date series of recorded visits to laboratories preserved on motion picture film and video tape.

Problem: Many types of research require long periods of contact and/or collaboration between scientists and engineers. Where highly experienced researchers are concerned, short visits are inadequate to permit either the visitor or the visited staff to acquire full benefits from the visit.

Recommendation: That expansion and generalization of systems for exchanging researchers be undertaken, including greater use of sabbatical leaves for researchers in all disciplines, and greater freedom of exchange among different types of employing organizations.

Consultations

A characteristic behavior of researchers who need information is to ask friends and acquaintances for help. Scientists and engineers engage in time-consuming searches to find specialists whose ideas would be of value in conducting their research work. There is a strong feeling among researchers that they need better sources of information about who is specializing in fields related to their research problems.

Problem: The knowledge of the individual scientist as to who can give him information and advice concerning background, research design, procedures, and interpretations is limited. There is a general need for information concerning whom to consult, and the need is especially urgent when questions are related to other disciplines. Directories of scientists presently contain insufficient and out-dated information.

Recommendation: That systematic data be collected from specialists in various disciplines, covering previous research, current research, present address and telephone number, with a view toward establishing an easily accessible central index of research advisors.

Problem: Many researchers remain unaware of current government efforts to provide information and advice related to new research efforts.

Recommendation: That a plan be developed to publicize further the government's informal research information services.

Informal Information Exchange

Many researchers noted that they must consistently acquire up-to-date information about new and ongoing research in order to avoid duplicating the efforts of others and to properly integrate their results with results obtained from other studies. One way that they attempt to meet this need is by sending preprints or draft research reports to other researchers whom they believe to be interested in their work. Another method is through the publication of newsletters that briefly describe the work of others in a given research specialty.

Problem: The number of preprints being distributed in certain disciplines is becoming excessive and review and theoretical papers are included without necessity. Many who could benefit from a preprint may not receive a copy.

Recommendation: That a study be made of current science news services and preprint services with a view toward establishing a system that coordinates newsletter dissemination of news about research in specialties and a central preprint repository that can supply copies of draft reports on request.

National Security

A number of comments concerning problems of classified information for national security purposes were received which indicate a belief that it might be possible to reduce restrictions on the exchange of scientific and technological information caused by national security requirements. It was said that security regulations delay the transfer of classified information, even to those who have a "need-to-know."

Problem: Methods of classifying information for security purposes are not always consistent and frequently peripheral knowledge is classified unnecessarily.

Recommendation: That studies be made concerning the consistency of classification requirements and procedures and the rapidity with which declassification can be accomplished after security classification is no longer needed.

Problem: Researchers with a valid "need-to-know" are hampered in acquiring information when the information must be obtained from a military service other than the one that sponsors their research.

Recommendation: That a study be made to investigate the feasibility of establishing rapid "need-to-know" clearance procedures that are commonly acceptable among all government services.

Problem: Many scientists apparently are not familiar with current procedures to obtain classified information. Young researchers, in particular, feel left out of the important channels of information about classified research activities.

Recommendation: (1) That training efforts be increased to inform researchers concerned with possible security matters as to procedures required to obtain classified information; (2) that classified symposia be developed to inform young researchers of the basic areas of research involved with classified matters that are in their fields of interest.

Proprietary Interests

In addition to restrictions generated by national security requirements, proprietary interests of profit-making corporations also limit the transfer of scientific and technological information.

Problem: Proprietary information frequently is not as secret or as unknown as sometimes is believed by those who place constraints on its transfer. The fear of theft or misuse of ideas creates barriers to communication which are often necessary.

Recommendation: (1) That a policy of wide-open exchange of research information be encouraged, and (2) that cross-licensing, such as exists in the electronics industry, be encouraged.

Problem: Policies involving evaluation of researchers are now mainly based on number of publications, and meeting attendance often is limited to paper readers. Such policies as these lead to an over-production of trivial papers and publications that usurp valuable time because vested financial interests are generated in researchers unnecessarily.

Recommendation: That compensation and reward policies that sustain the "publish or perish" philosophy be reviewed and revised so as to improve methods of evaluating researchers' productivity and to reduce trivial information output.

Costs of Informal Research Communications

An effort was made during the present investigation to obtain cost estimates for informal communications directly from the researchers on questionnaires and on Incidents Memos.

Problem: Accurate estimates of costs of informal communications are needed as a basis for decisions concerning allocation of research funds, but survey methods were found to be inadequate for this purpose.

Recommendation: That accounting studies be made on national samples to establish accurately the direct and indirect costs of informal research communications.

Unexpected Research Events

Problem: Events that arise unexpectedly during research often cannot be dealt with properly because funds were not included in cost estimates that could be used to cover them.

Recommendation: That contingency funds be established in order to enable quick responses to be made to unexpected problems, such as new developments and needs for basic research uncovered during applied research.

Meetings, Conferences, and Courses

A large number of criticisms and suggestions concerning meetings of national research societies were reported. But considerable variation was noted between disciplines in this respect.

Problem: Each national research society has special problems concerned with organization, structure, and location of meetings, conferences, and courses.

Recommendation: (1) That each national research organization be provided with the support necessary to determine and solve its own special problems concerning informal information services for its members, and (2) that a study be made of universities to determine what is needed to enhance their role in post-graduate research training and in sustaining researchers' efforts to remain up-to-date in their specialti

Contract Administrators

A number of research leaders noted that they frequently are required to enter into contract negotiations and monitoring situations with government contracting officers who are inadequately equipped, scientifically and/or technologically, to comprehend the problem of researchers who are endeavoring to do creative work.

Recommendation: (1) That an increased effort be made to have research contract administrators be especially selected and trained in dealing with problems of creative research, and (2) that consulting services be made available to them by disinterested specialists from universities and/or from institutes established for this purpose.

APPENDIX I

SCIENTIFIC AND TECHNICAL COMMUNICATION INCIDENT MEMO

Name ______________________ Organization ______________________

Incident Location ____

Date ______________ Time Required ______________ Estimated Cost ______________

CHECKLIST

Type of Communication	Source: Initiated	Source: Received	Communicator: Supervisor	Communicator: Co-Worker	Communicator: Consultant	Communicator: Supplier	Communicator: User	Communicator: Editor	Communicator: Author	Communicator: Other*
Telephone Call										
Conversation										
Office Conference										
Letter										
Memorandum										
Pre-Publication										
Proposal										
Journal Article										
Specification										
Other *										

* ____

Topic: ____

Incident Abstract: (Please print or write clearly)

Result: ____

Value:	Exceptional	High	Moderate	Useless	Unknown

American Institutes for Research
Silver Spring, Maryland

APPENDIX II

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American Institute for Research
Silver Spring, Maryland

Exploration of Informal Scientific and Technical Communication

INTRODUCTION TO THE INTERVIEW

As you already know, we are exploring informal scientific and technical communications. The main purpose of this interview is to obtain additional examples of your experiences with informal scientific and technical communications. We are now only interested in communications that occurred before you began to observe incidents for our study. Now we want to obtain an understanding of how informal communications have affected your research work. Our interview will be treated as confidential information, and it will be used only for research purposes. Secret information or proprietary ideas should be described only in general terms without revealing confidential information.

The interview will take only about one hour. We use a tape recorder because it enables us to transcribe your answers exactly. Your tape recording will be interpreted by a consultant who is a specialist in your own professional field. The transcripts of the interviews will be evaluated by content analysis over all observers. We shall also base our analysis on the frequency of occurrence of each kind of example that is reported. May I turn on our tape recorder?

(Turn on tape recorder and say:)

May I have your full name?
What is the correct spelling of your name?
And what is the name of your organization?
What is the title of your present job?
And what is your professional specialty?

(Proceed to interview questions)

Part I: Open-ended questions.

Gathering Technical Information

1. When you need scientific or technical information, how do you go about obtaining it informally?

2. What outside sources of paid consultants have you utilized?

3. How does newness of a research area affect what you do? Example?

4. Do you communicate regularly with a group of colleagues outside of your organization about scientific or technical problems? Examples? Value?

5. How do you keep your general background of knowledge up-to-date by means of informal communications?

6. Do you attend monthly meetings of a local professional society?

   a. If "Yes": Please describe the most valuable kinds of meetings. Why are they most valuable?

   b. If "No": Would you attend monthly meetings of a local professional society if they were available? If not, why not?

7. How do informal communications enter into inter-disciplinary research? Examples? Results?

8. Which phases of the research process require most informal scientific or technical communications? Why?

9. Please give some examples of how informal methods brought you information that was difficult to obtain.

10. Have you had problems in obtaining time or funds to complete informal scientific or technical inquiries? Examples?

Informal vs. Formal Communications

11. Which types of scientific or technical information are best communicated by informal means? Example?

12. Please give an example of how informal communications and published material complemented each other to supply you with information.

13. In what way are informal communications essential to the transfer of scientific and technical information? Examples?

14. How are informal technical communications supported by your organization? Example?

15. Please give an example of how an informal communication contributed to an innovation.

16. Please give an example of how informal communications contribute to research motivation?

Recommendations

17. How can we improve informal technical communications over long distances?

18. What can be done to improve meetings of scientific and technical societies?

19. What would help to improve scientific and technical conferences within your organization?

20. What else can be done to improve informal scientific and technical communications in general?

Intra-Organization Channels

21. Which individual within your organization supplies most of your informal scientific and technical information? How often each month, on the average?

    a. What is his position in your organization?

    b. What is the extent of his technical background?

22. What other individual informally supplies you with technical information within your organization? How often each month, on the average?

    a. What is his position in your organization?

    b. What is the extent of his technical background?

23. Are there any others? (Obtain answers for a. and b. as above for each other person mentioned, and how often each month).

24. Which individual in your organization most often comes to you for scientific and technical information? How often each month, on the average?

   a. What is his position in your organization?

   b. What is the extent of his technical background?

25. Is there another individual who comes to you? (Obtain answers for a. and b. as above for each other person mentioned, and how often each month).

26. Is there anything you would like to add to our discussion of informal scientific and technical communications?

Part II: Short-answer questions:

1. About what percent of your time is spent providing scientific and technical information to others by:

		Percent
a.	telephone calls?	(a)_____
b.	in-person conversation?	(b)_____
c.	letters and memoranda?	(c)_____
d.	prepublication drafts?	(d)_____
e.	laboratory conferences?	(e)_____
f.	technical society meetings?	(f)_____
g.	other? (specify)	(g)_____

2. About what percent of your time is spent in obtaining scientific and technical information by:

		Percent
a.	telephone calls?	(a)_____
b.	in-person conversations?	(b)_____
c.	letters and memoranda?	(c)_____
d.	laboratory conferences?	(d)_____
e.	technical society meetings?	(e)_____
f.	other? (specify)	(f)_____

3. Please rate the following types of communication according to their value to you for providing current information. Designate your rating with the corresponding letter:

A = Very valuable.
B = Moderately valuable.
C = Slightly valuable.
D = No value.

		Rating
a.	Listening to papers at technical society meetings.	(a)_____
b.	Listening to papers at conferences.	(b)_____
c.	Presentations at seminars.	(c)_____
d.	Reports from assistants (students).	(d)_____
e.	Conversations with colleagues here.	(e)_____
f.	Conversations with colleagues elsewhere.	(f)_____
g.	Letters.	(g)_____
h.	Memoranda.	(h)_____
i.	By telephone.	(i)_____
j.	Preprints.	(j)_____
k.	Journals.	(k)_____
l.	Abstracts.	(l)_____
m.	Books.	(m)_____

4. How many copies of preprints do you mail each year? ________

5. About how many copies of preprints do you receive each year? ________

6. Are you in favor of developing further the distribution of preprints? ________

7. Do you receive an informal "newsletter" concerning activities of your field of specialization? ________

8. Do you find newsletters to be valuable? ________

9. During the past two years, has your organization granted you a leave-of-absence to accept an appointment elsewhere? ________

10. How frequently do scientists or engineers from other institutions accept temporary assignments with your organization? ________

11. How often do you visit out-of-town laboratories to discuss scientific and technical problems? ________

12. Are you reluctant to discuss your new research plans with people outside of your own laboratory or department? ________

13. Consider the payoffs from time spent on informal scientific and technical communications. Are the costs in time (check one):

    a. much too high? (a) ______
    b. moderately high? (b) ______
    c. fairly low? (c) ______
    d. very low? (d) ______

14. In terms of the time you spend on informal scientific and technical communications, do you (check one):

    a. have enough time? (a) ______
    b. need somewhat more time? (b) ______
    c. need much more time? (c) ______

15. Which do you feel most stimulates action to complete new research (check one):

    a. informal communications? (a) ______
    b. formal communications? (b) ______

17. About how many meetings of scientific and technical societies do you attend each year? ________

18. Would it be to your advantage to have available monthly meetings of a professional society in your field? ________

19. About how much of your organization money do you spend each month for informal scientific and technical information by:

    a. telephone? (a) ______
    b. travel for personal discussions? (b) ______
    c. letters and memoranda (include secretary's cost)? (c) ______
    d. prepublication drafts? (d) ______
    e. technical society meetings? (e) ______
    f. other (specify)? (f) ________________

20. Consider the payoffs from organization money spent on informal communications. Are the costs (check one):

a.	much too high?	(a)_____
b.	moderately high?	(b)_____
c.	fairly low?	(c)_____
d.	very low?	(d)_____

21. Consider the organizational funds that you spent for informal scientific and technical communications. Do you (check one):

a.	receive enough?	(a)_____
b.	need somewhat more?	(b)_____
c.	need much more?	(c)_____

22. Background Information:

a. Position Title______________________________

____

b. Highest degree earned__________ Year__________

c. Years of research experience ______________

d. Fields of major interest____________________

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Thank you for your assistance with our study.

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13. ABSTRACT

The report explored and defined the boundaries of informal scientific and technological communication, based on data from scientists and engineers. A major purpose of the report was to determine the kinds of management decisions needed to enhance research productivity by improving informal research communication.

The report includes: (1) a survey of current literature on research relating to informal scientific communications; (2) a summation of informal communications problems reported by research managers and their suggestions for improvement; and (3) an analysis of interviews, questionnaires, and critical incident reports supplied from 326 research project directors.

Data is reported on: (1) how informal and formal communications are interrelated; (2) how difficult-to-obtain information is located; (3) the values of informal research communications; (4) effects on research motivation and innovation; (5) informational exchanges and newsletters; (6) intra-organization communications; (7) inter-disciplinary communications; (8) directories of specialists; (9) visiting of other laboratories; (10)meetings and conferences; (11) use of communications technology (12) restrictions on information transfer; and (1_) the functions of informal communications in the research process.

The evidence produced by the participating research project directors testified to their broadness of perspective, and to the importance that they attach to problems of informal communications. The report substantiates values they place on informal communications to a very high degree. A list of overall problems and recommendations completes the report.

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